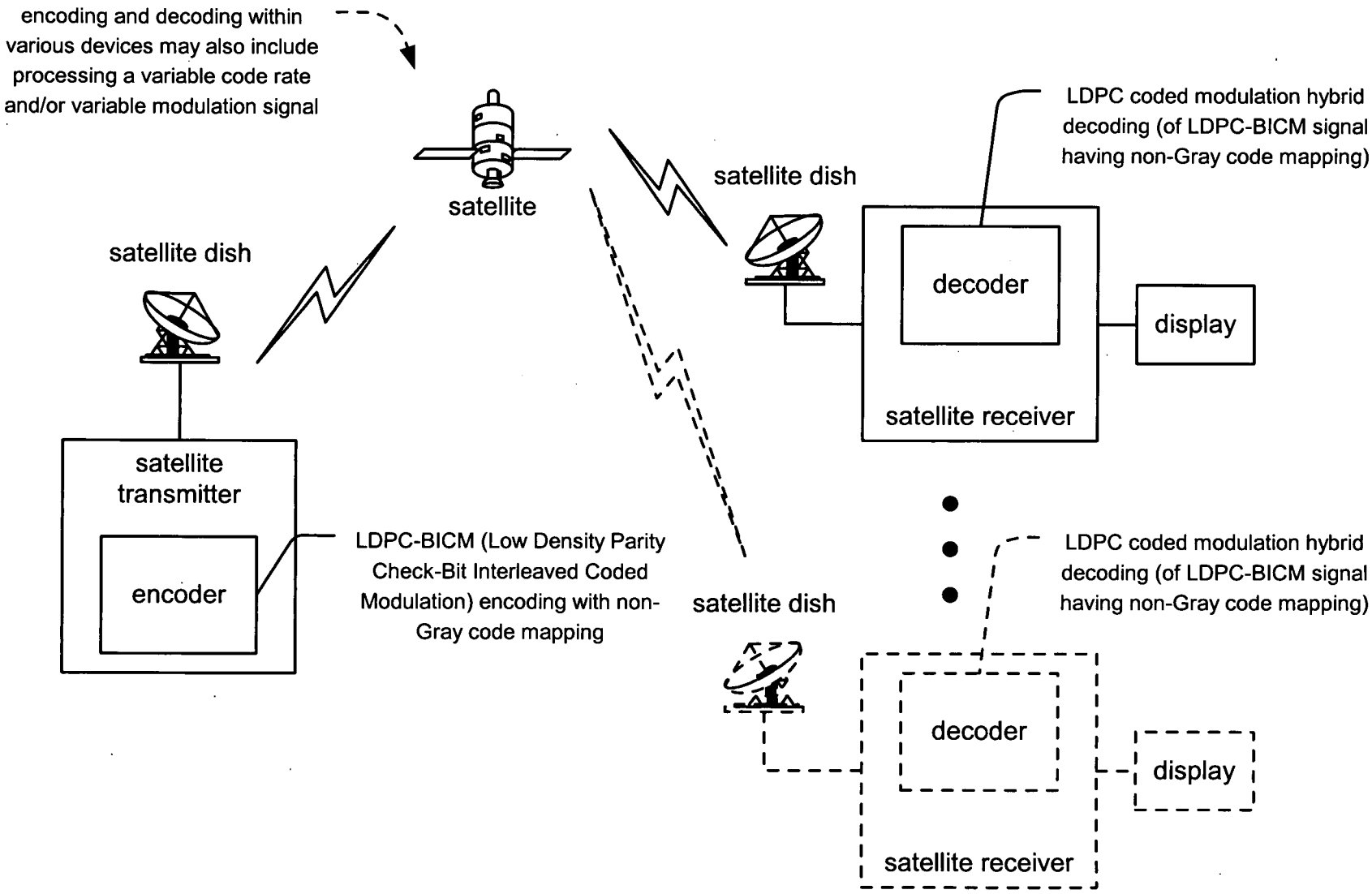
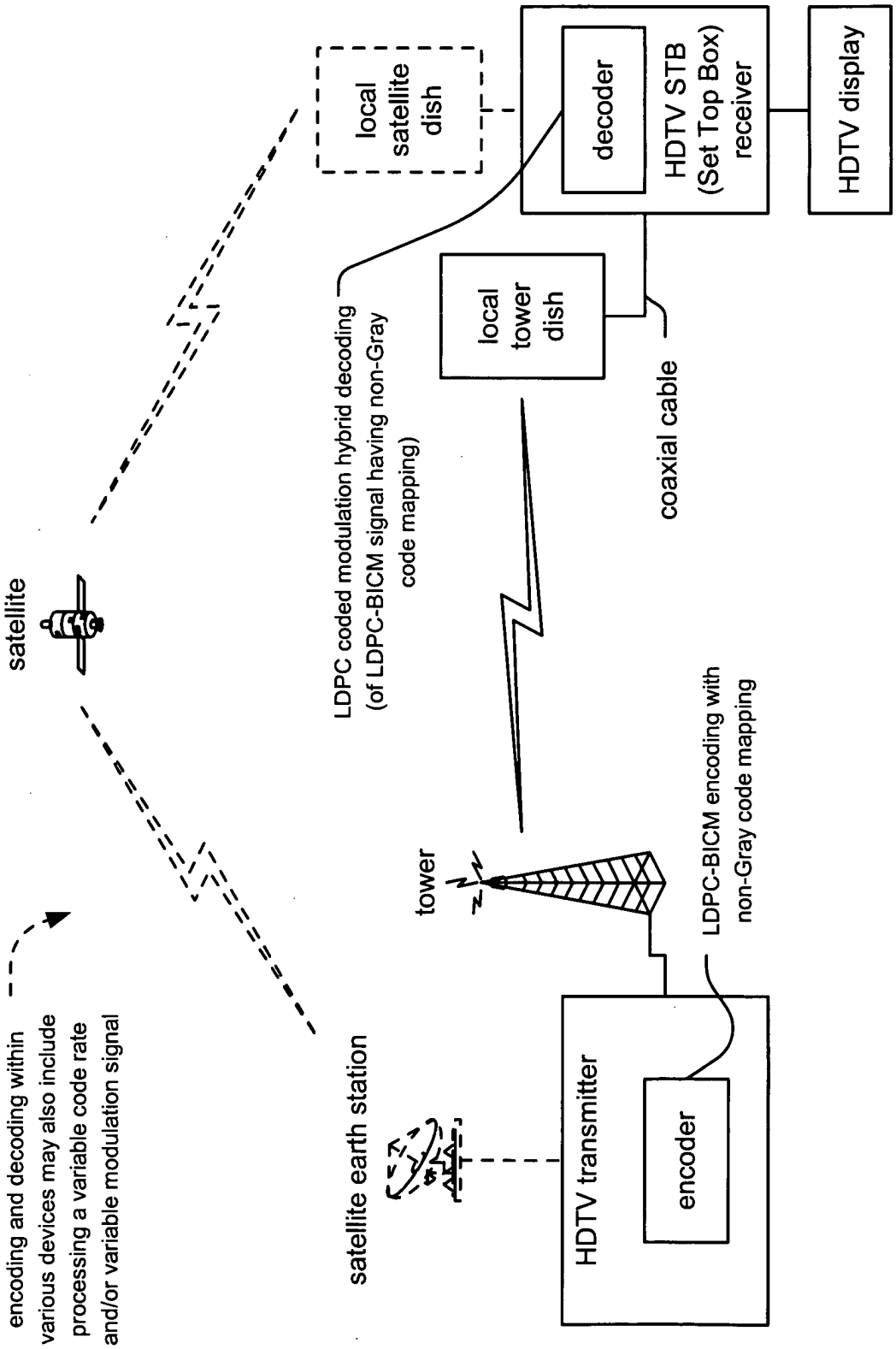


satellite communication system

Fig. 1



HDTV (High Definition Television) communication system

Fig. 2

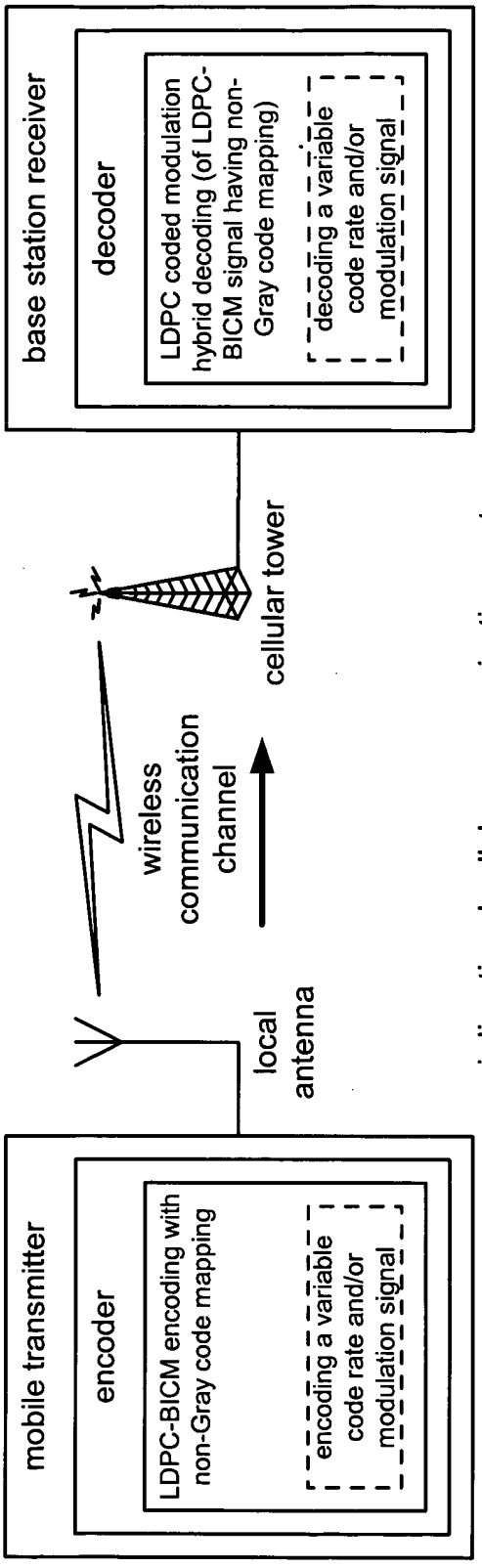

mobile transmitter
encoder
LDPC-BICM encoding with non-Gray code mapping
encoding a variable code rate and/or modulation signal
local antenna
wireless communication channel
cellular tower
base station receiver
decoder
LDPC coded modulation hybrid decoding (of LDPC-BICM signal having non-Gray code mapping)
decoding a variable code rate and/or modulation signal
uni-directional cellular communication system

Fig. 3A

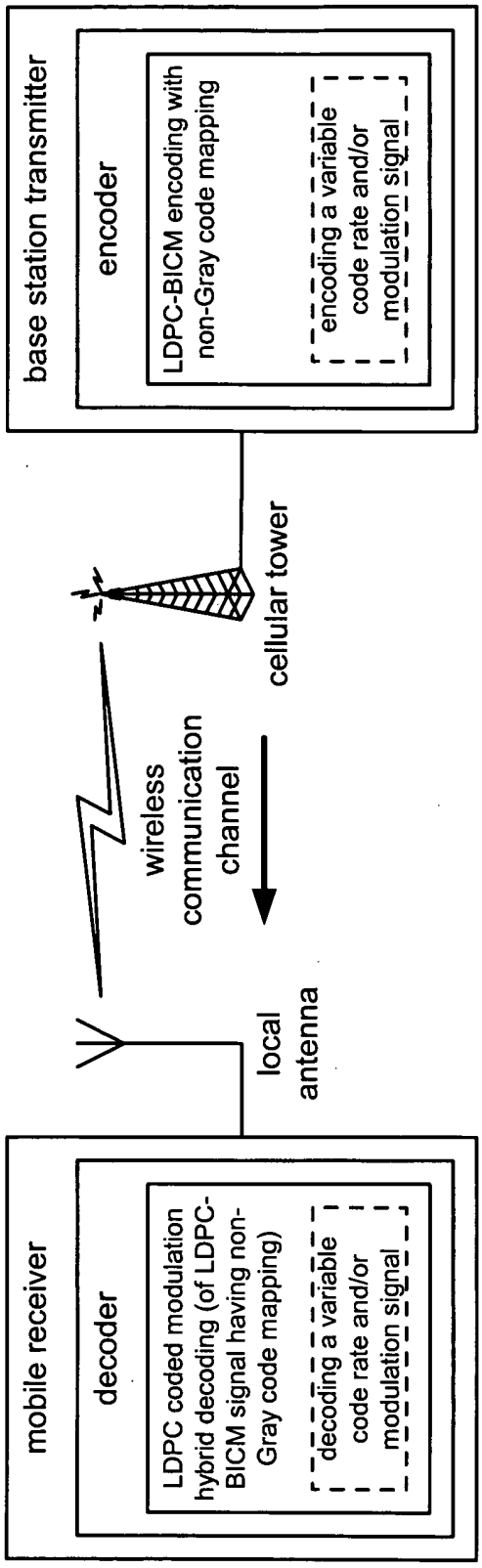
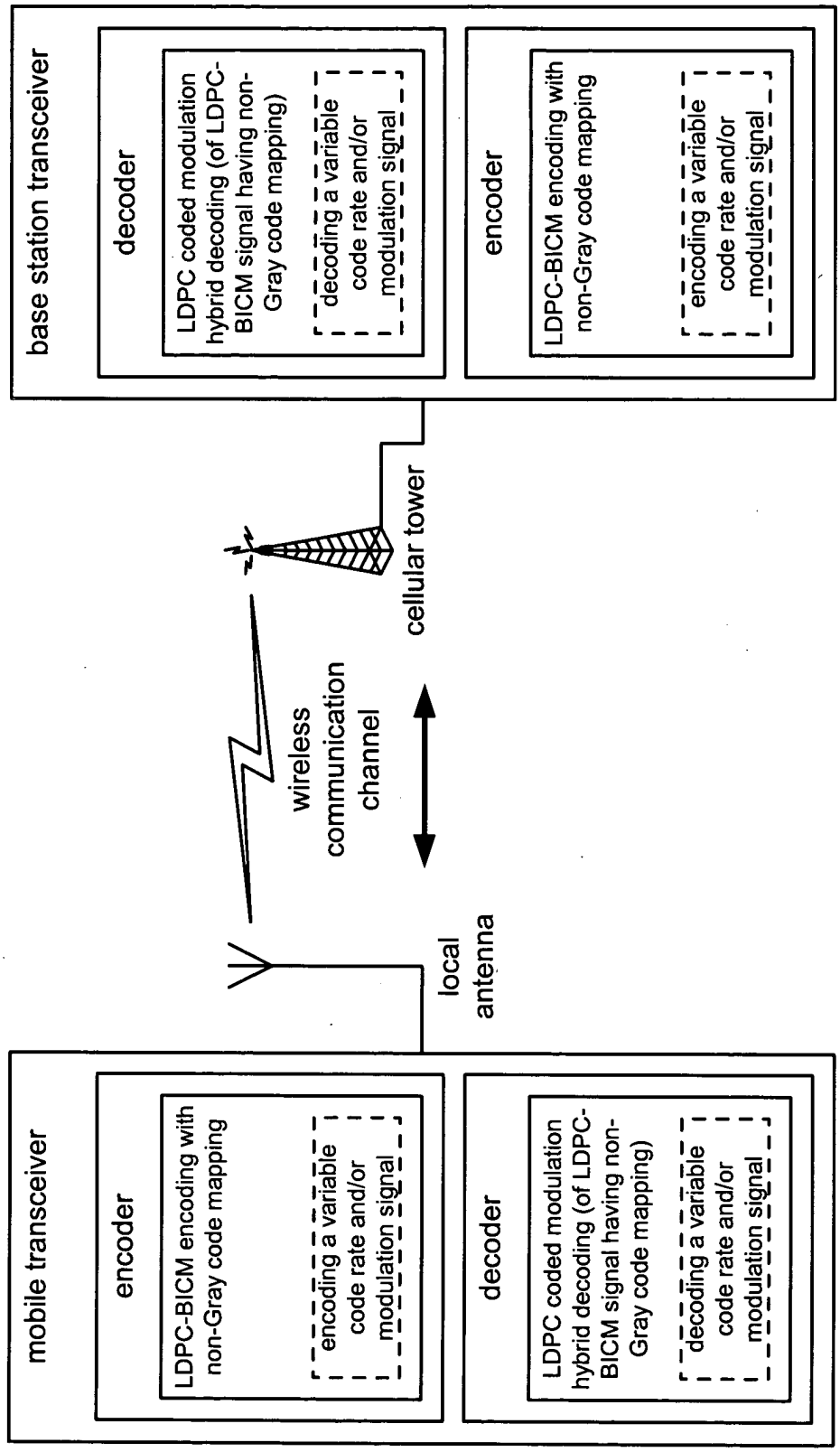
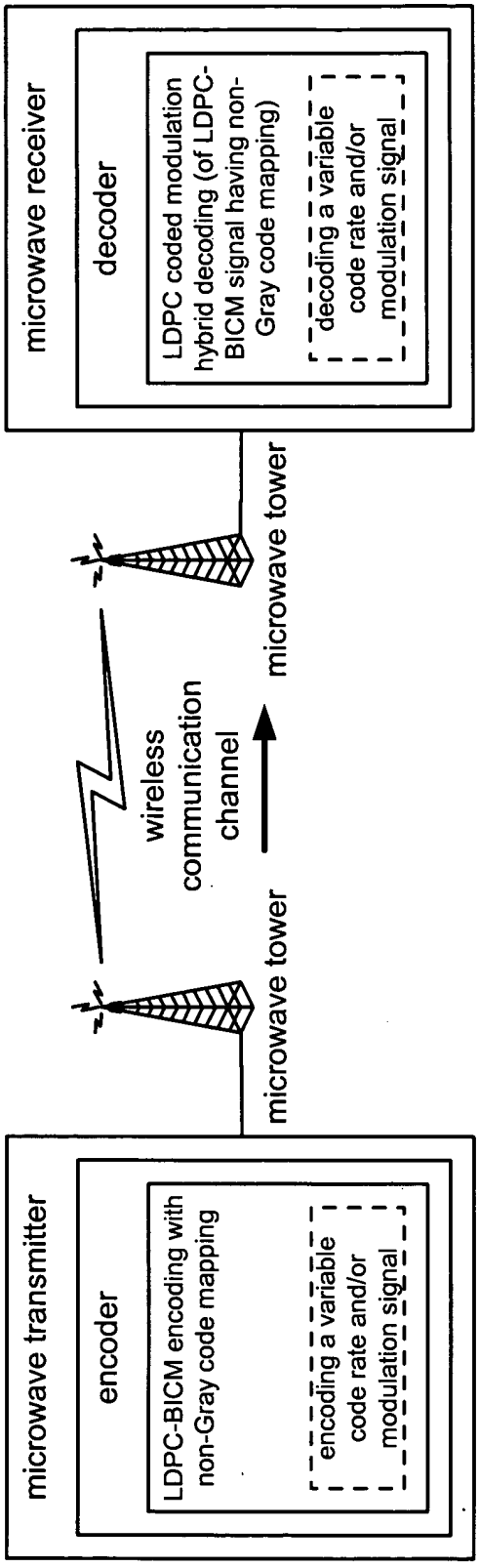

base station transmitter
encoder
LDPC-BICM encoding with non-Gray code mapping
encoding a variable code rate and/or modulation signal
wireless communication channel
cellular tower
local antenna
mobile receiver
decoder
LDPC coded modulation hybrid decoding (of LDPC-BICM signal having non-Gray code mapping)
decoding a variable code rate and/or modulation signal
uni-directional cellular communication system

Fig. 3B



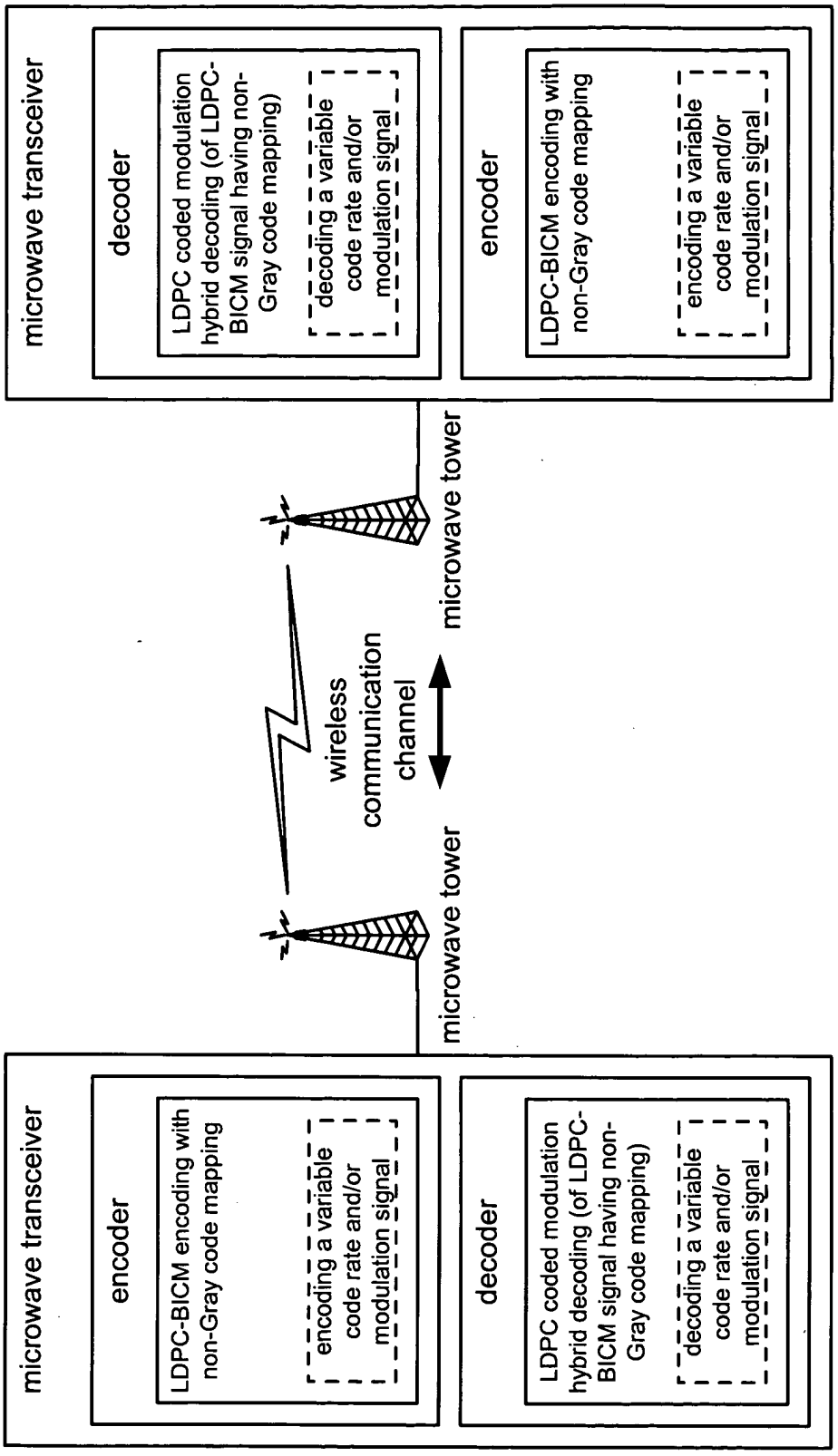
bi-directional cellular communication system

Fig. 4



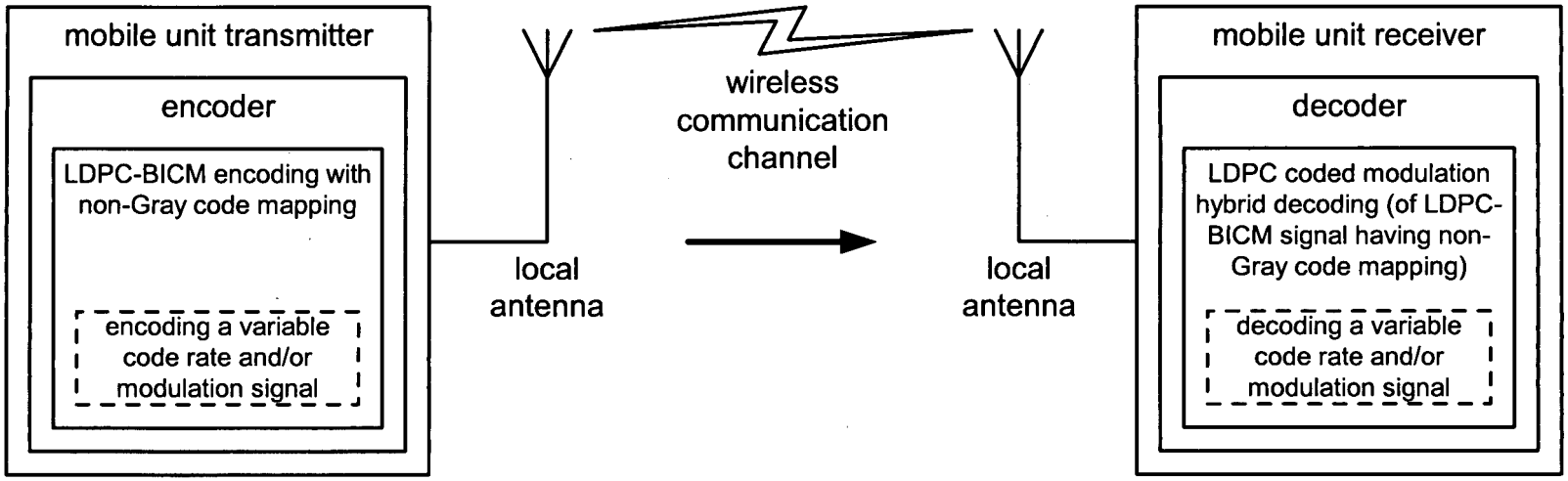
uni-directional microwave communication system

Fig. 5



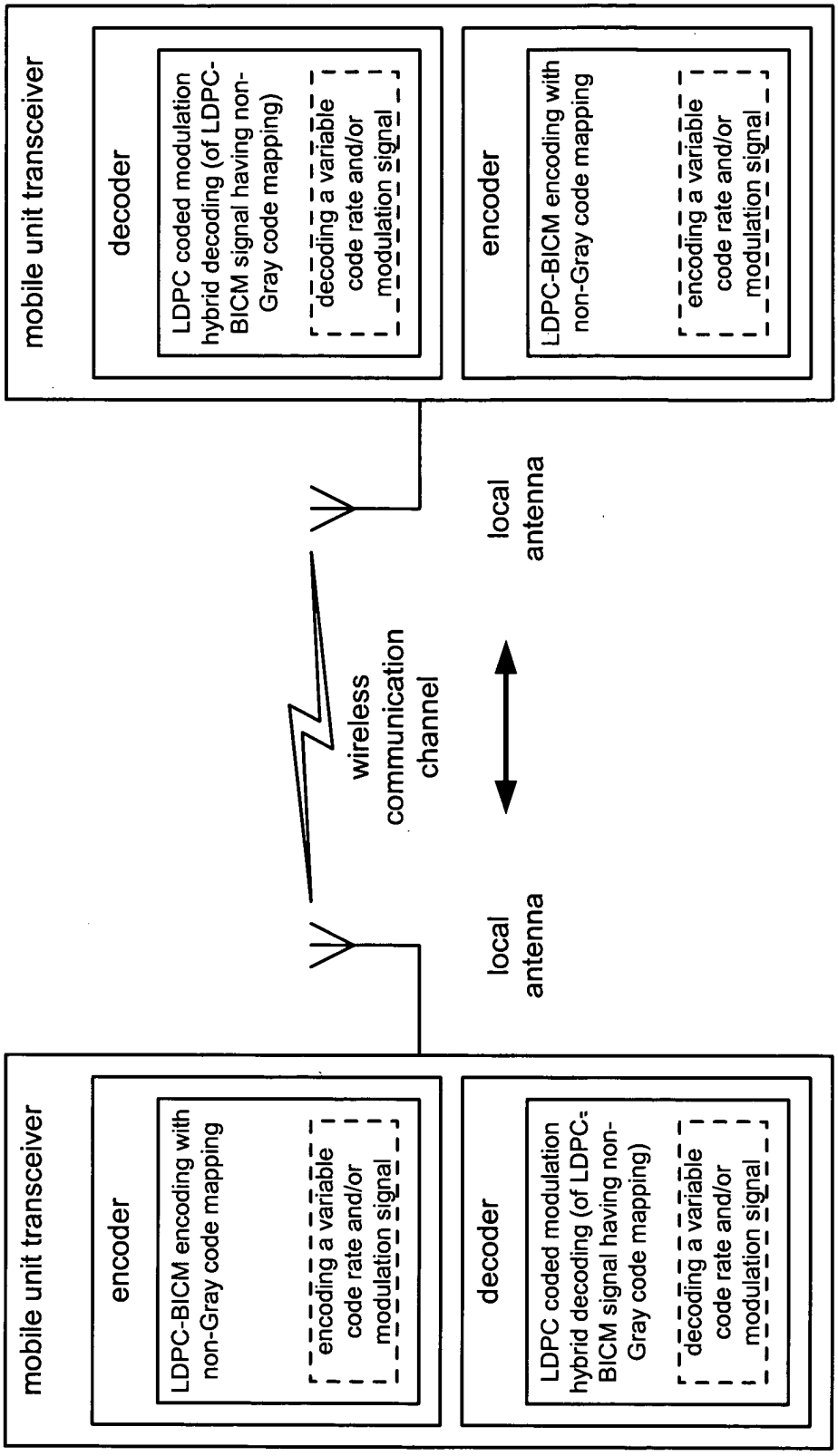
bi-directional microwave communication system

Fig. 6



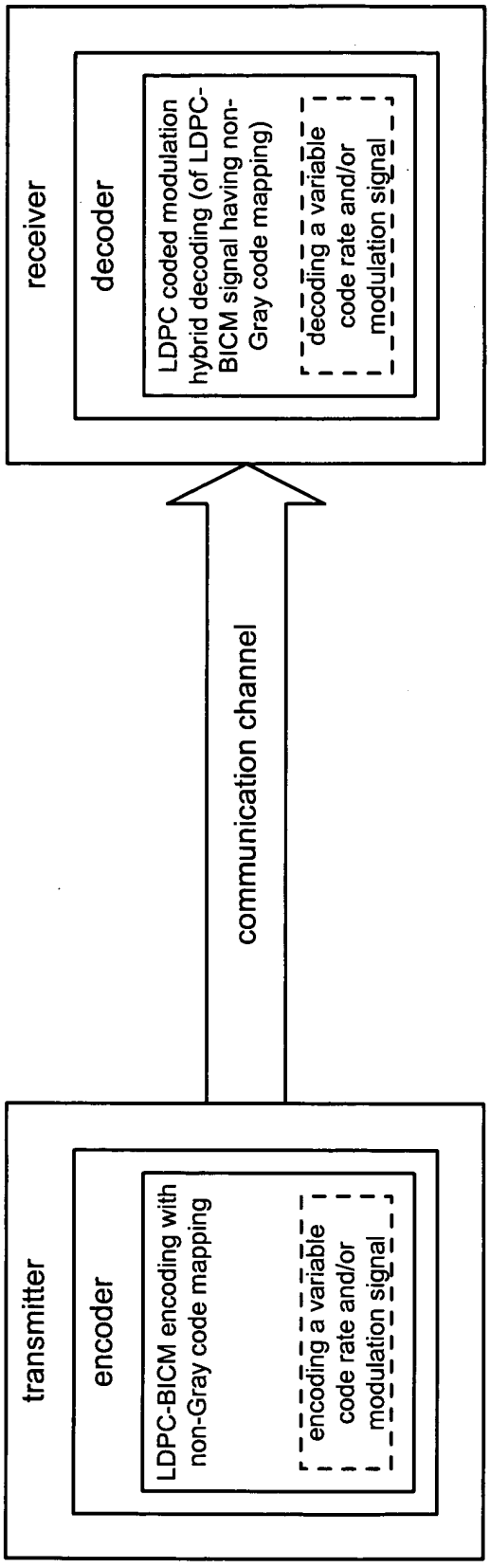
uni-directional point-to-point radio communication system

Fig. 7



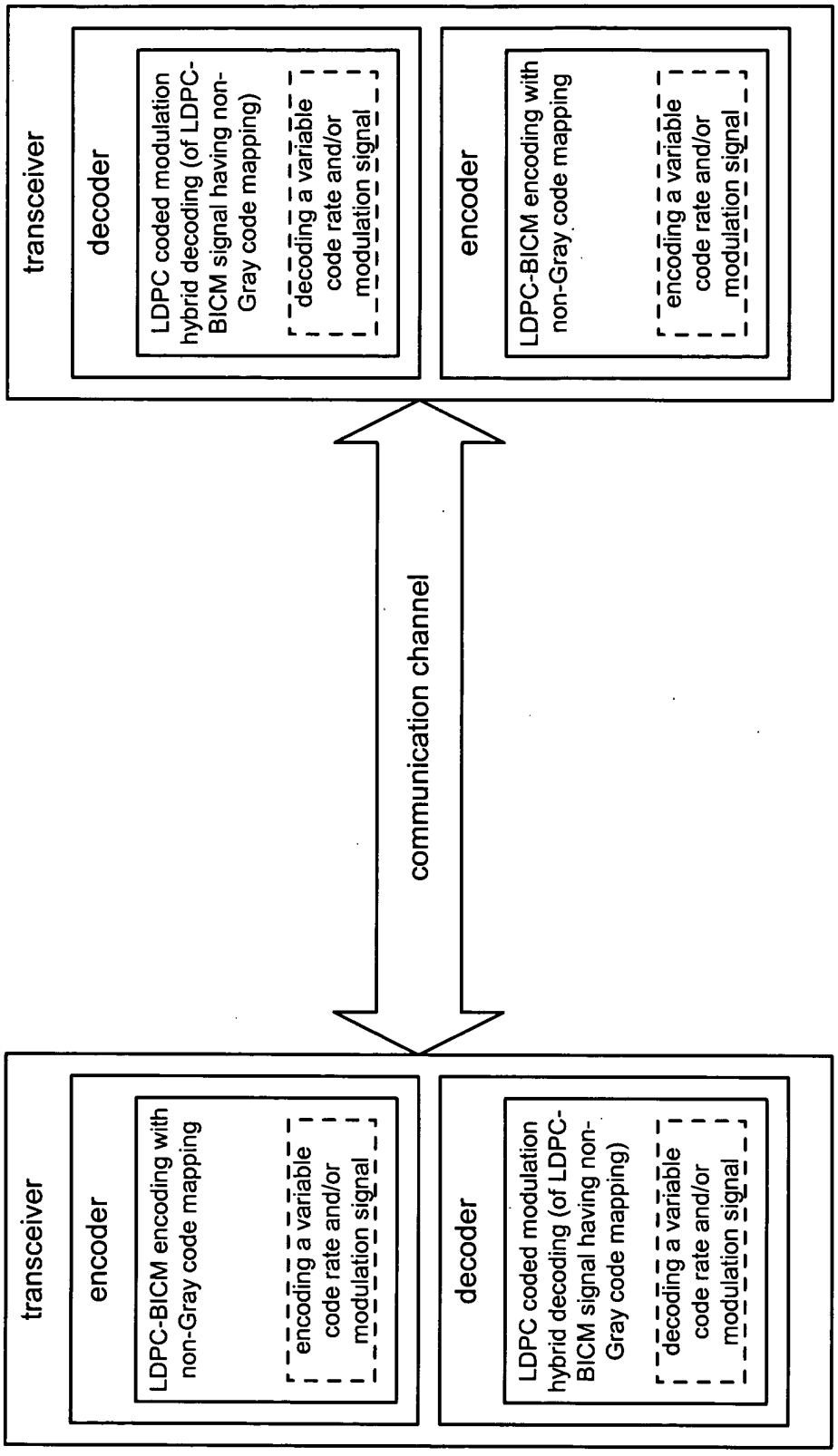
bi-directional point-to-point radio communication system

Fig. 8



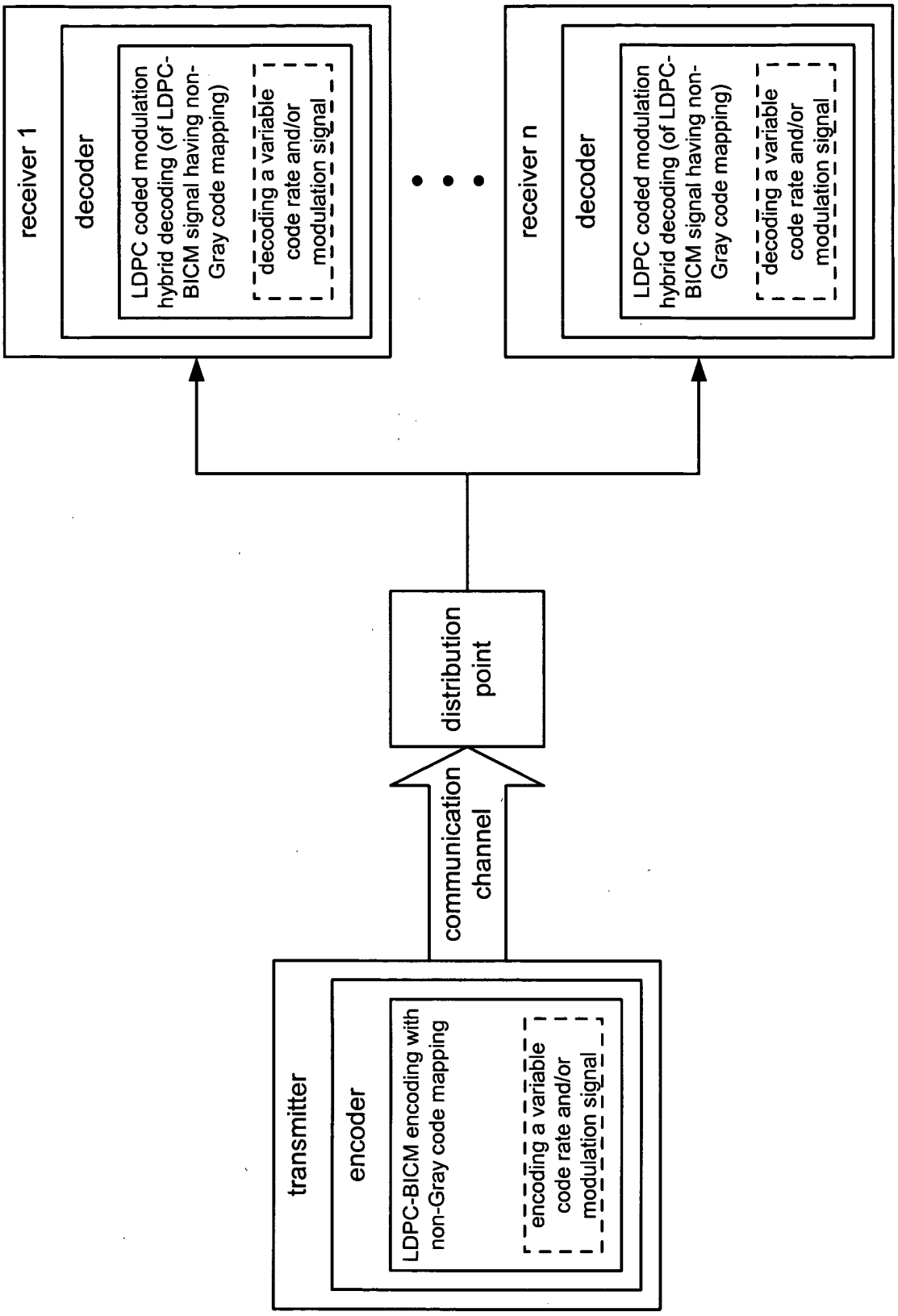
uni-directional communication system

Fig. 9



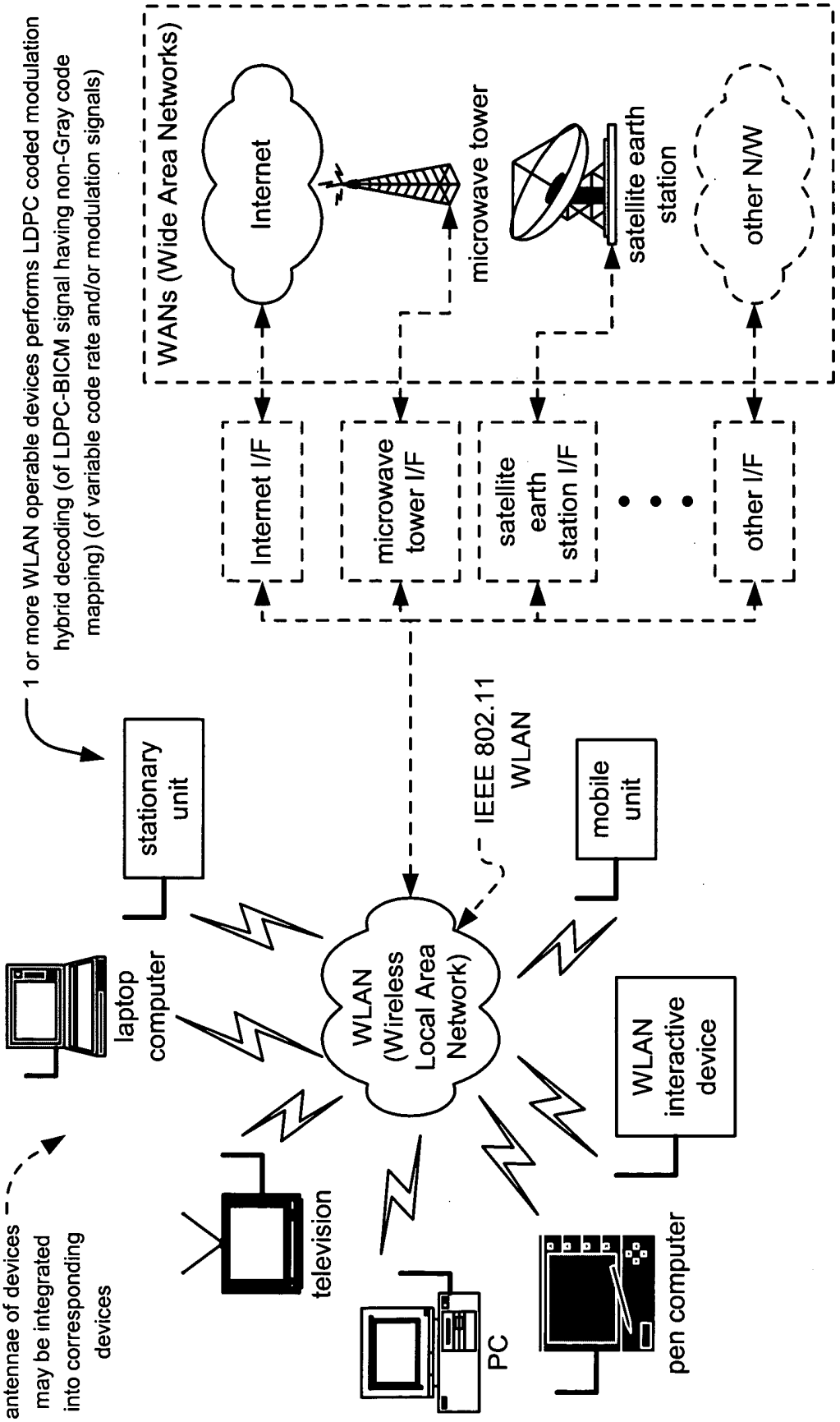
bi-directional communication system

Fig. 10



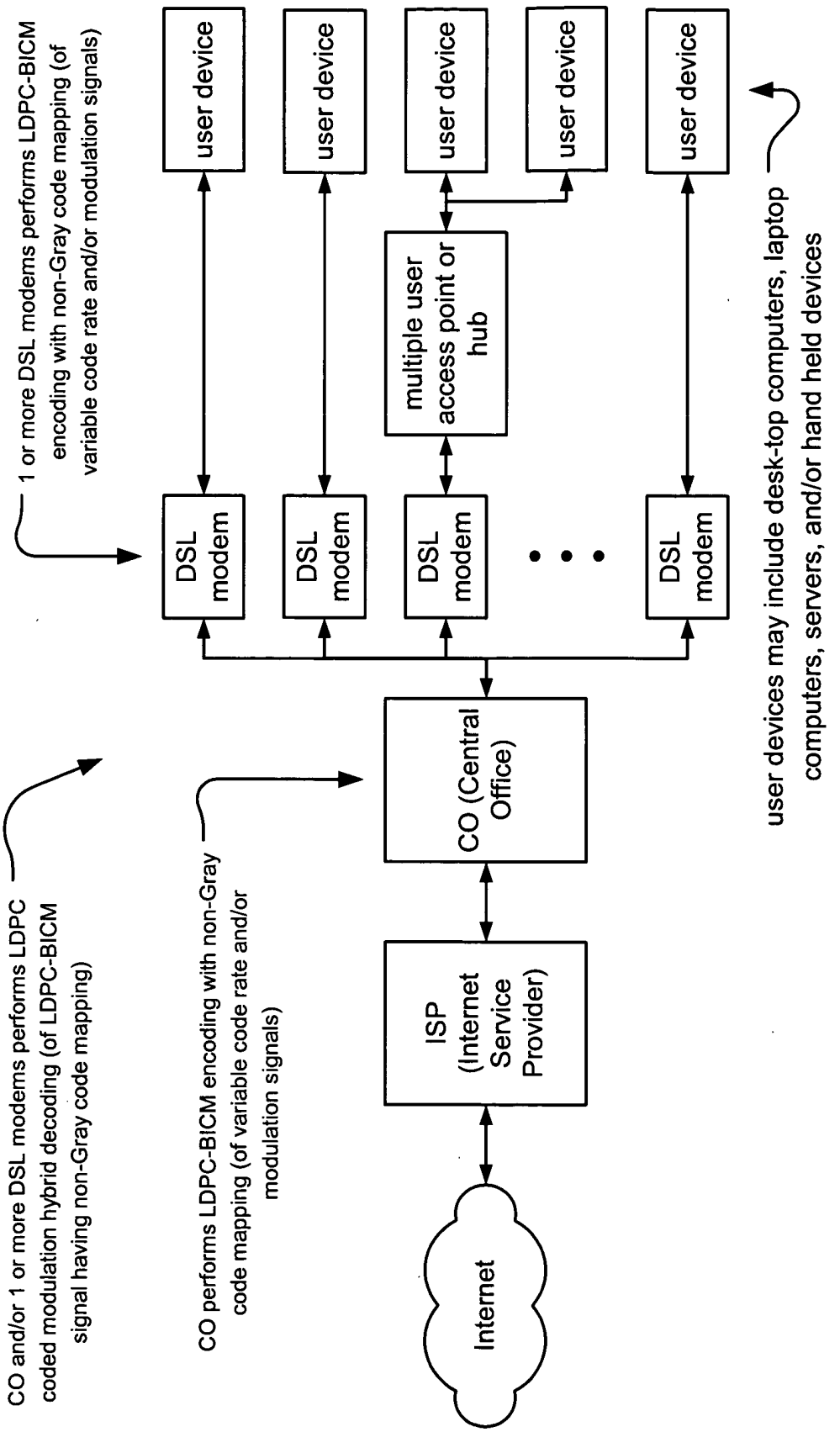
one to many communication system

Fig. 11



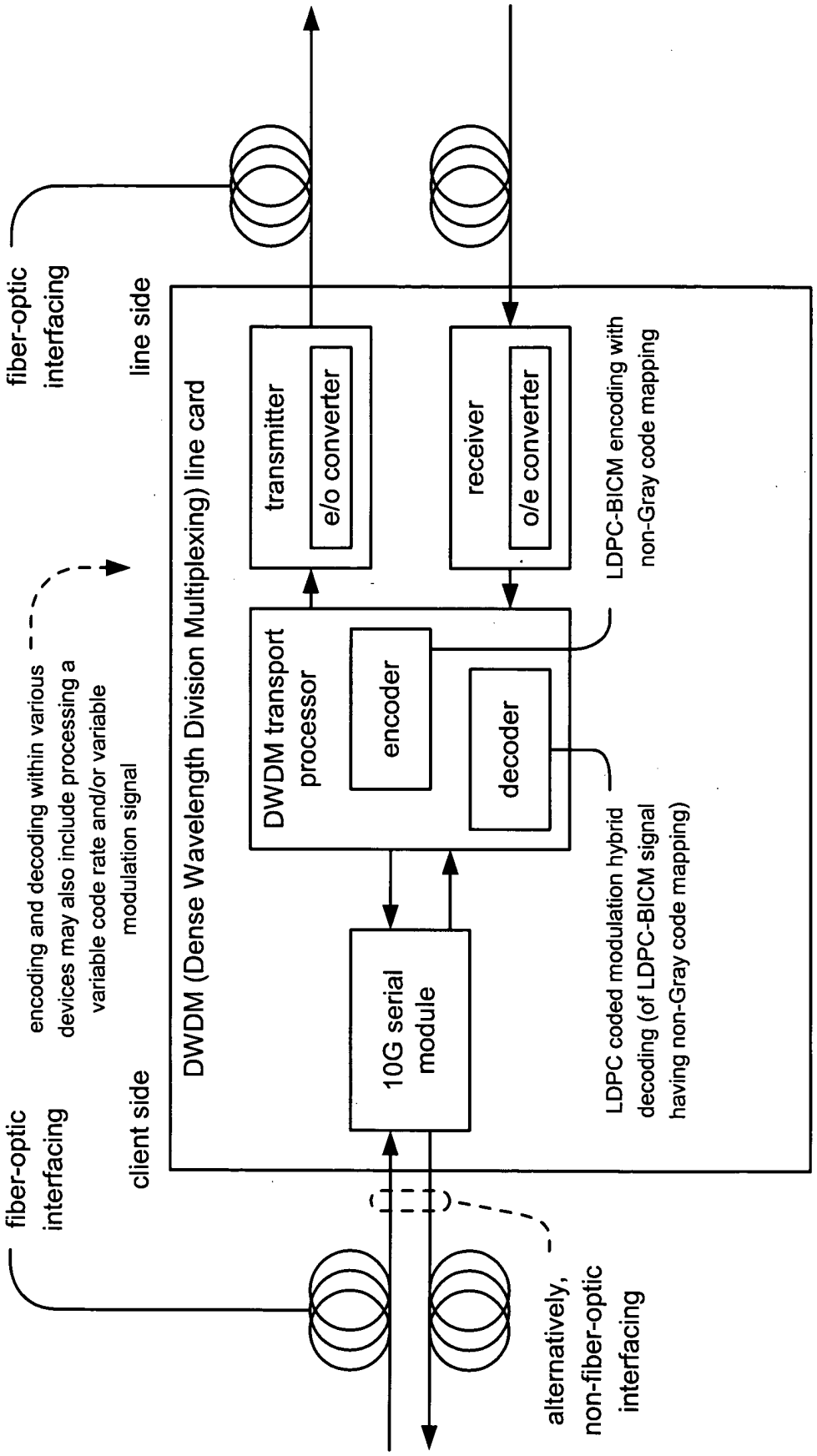
WLAN (Wireless Local Area Network) communication system

Fig. 12



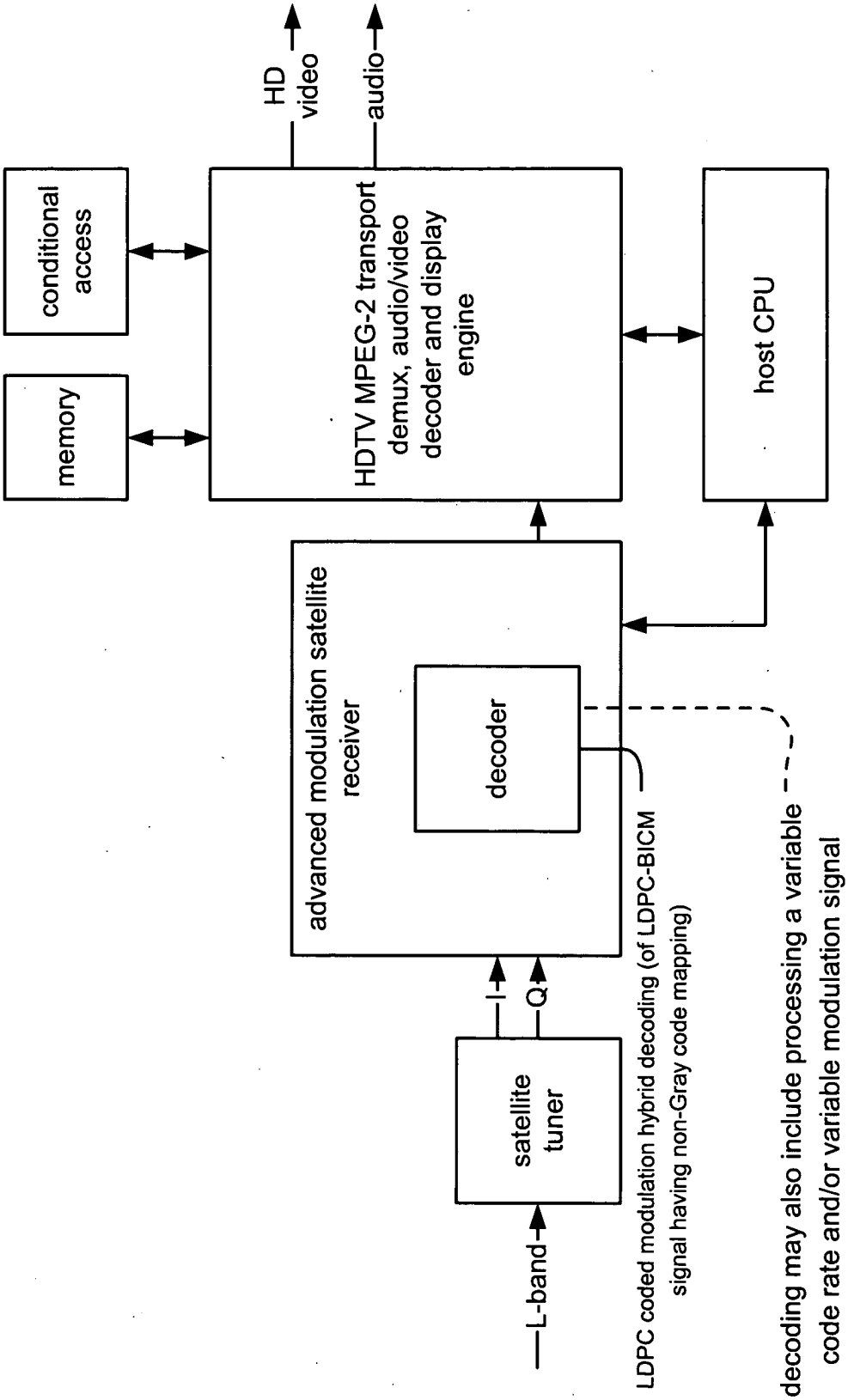
DSL (Digital Subscriber Line) communication system

Fig. 13



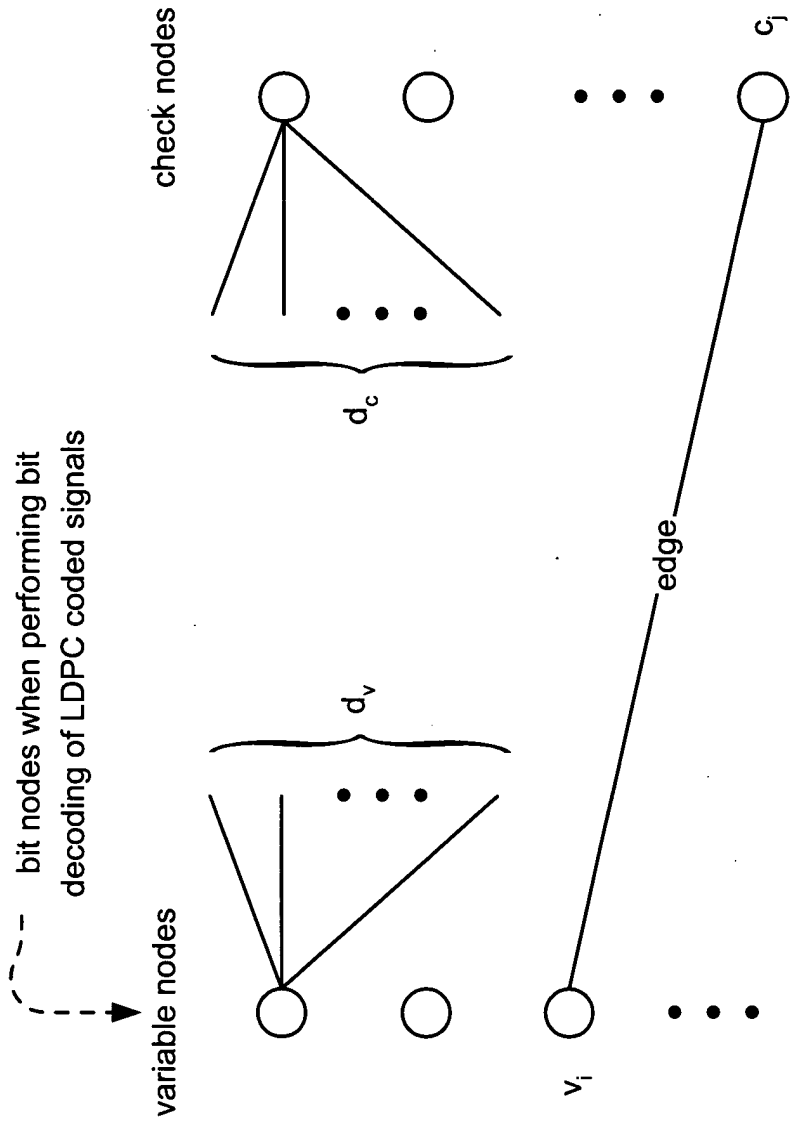
fiber-optic communication system

Fig. 14



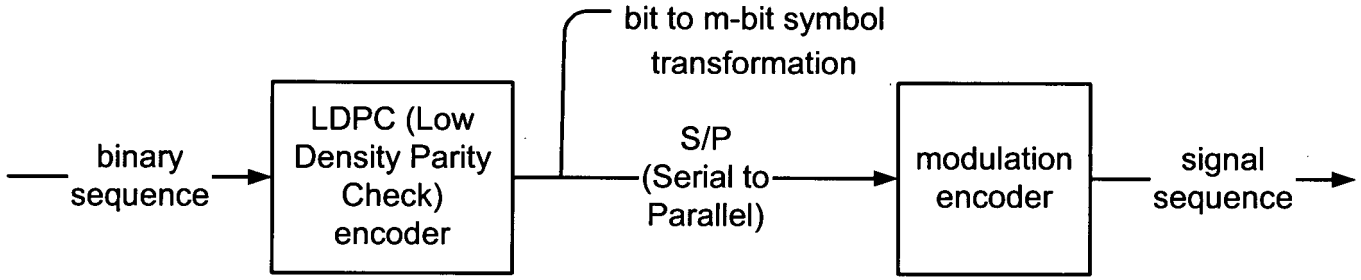
satellite receiver STB (Set Top Box) system

Fig. 15



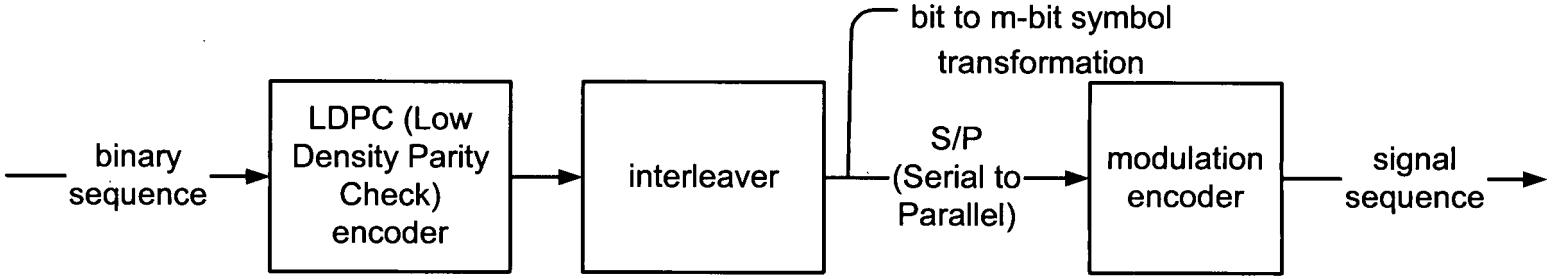
LDPC (Low Density Parity Check) code bipartite graph

Fig. 16



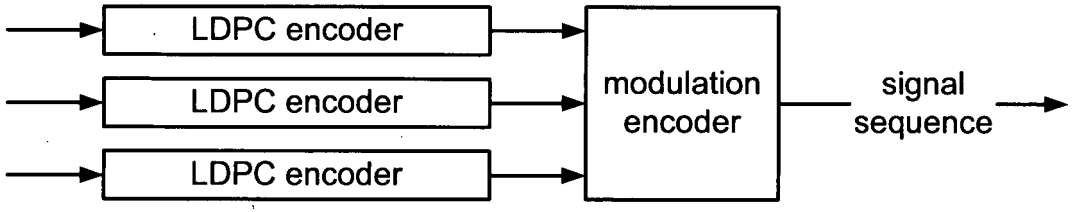
direct combining of LDPC (Low Density Parity Check) coding and modulation

Fig. 17A



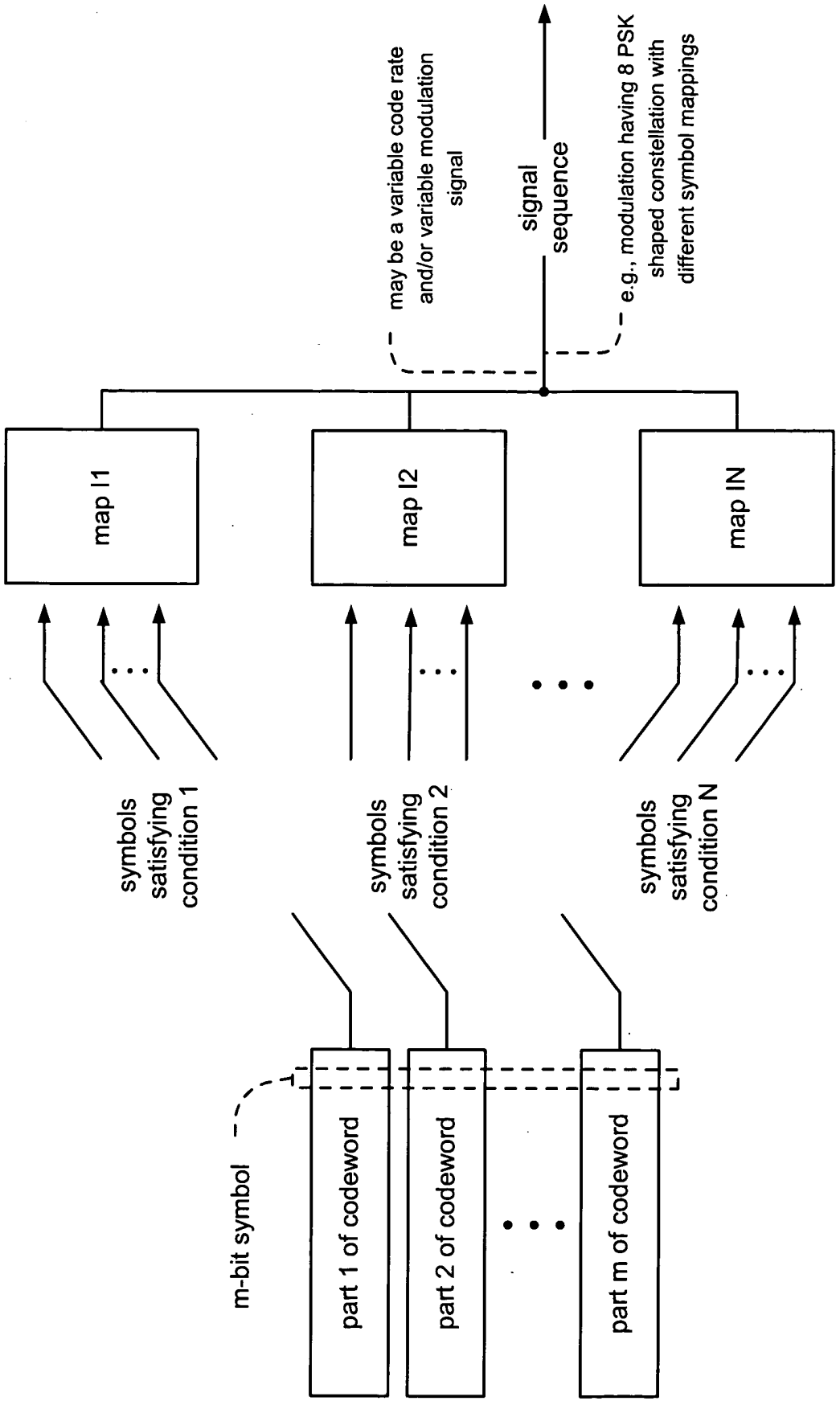
BICM (Bit Interleaved Coded Modulation)

Fig. 17B



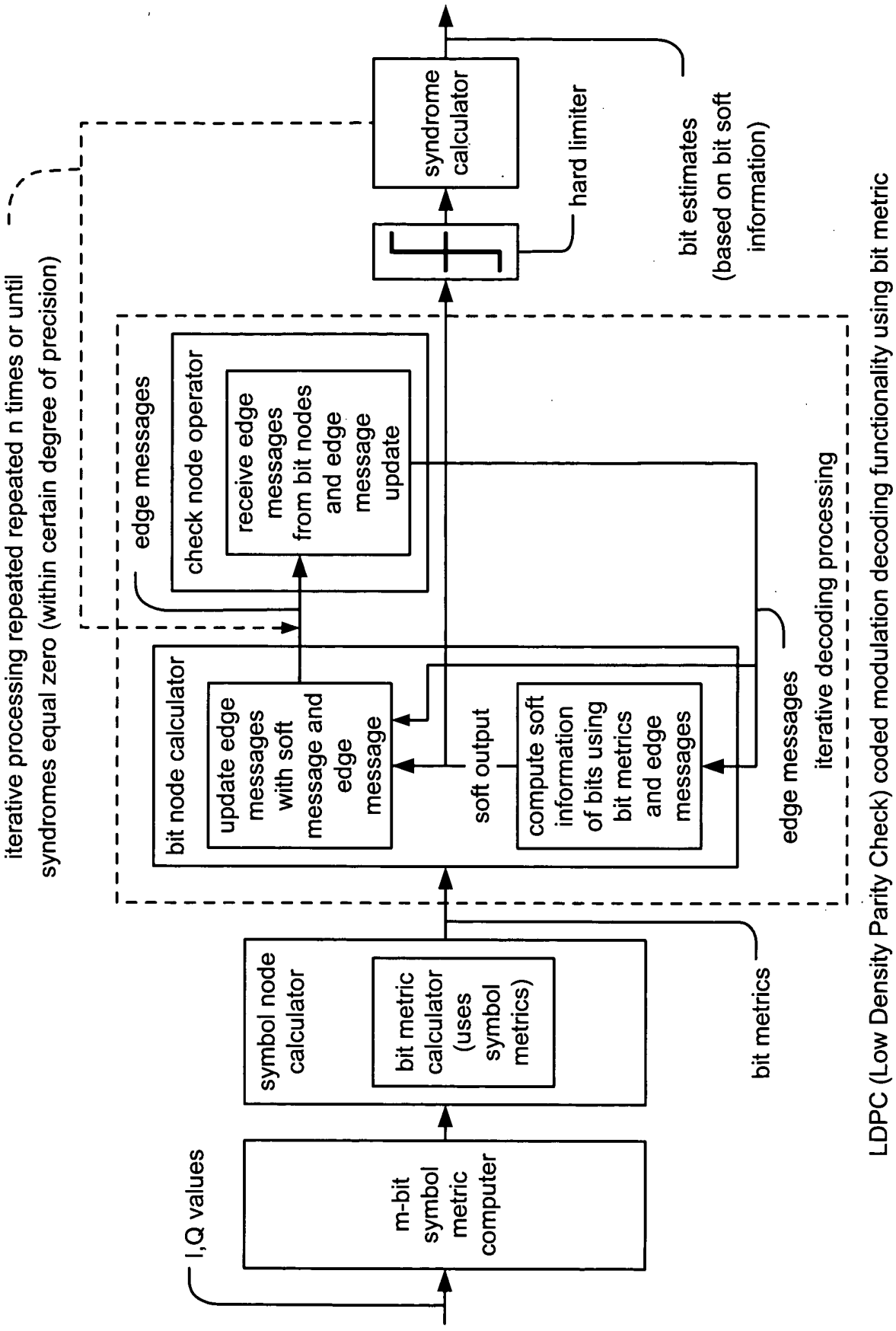
multilevel coded modulation

Fig. 17C



variable signal mapping LDPC (Low Density Parity Check) coded modulation system

Fig. 18



LDPC (Low Density Parity Check) coded modulation decoding functionality using bit metric

Fig. 19

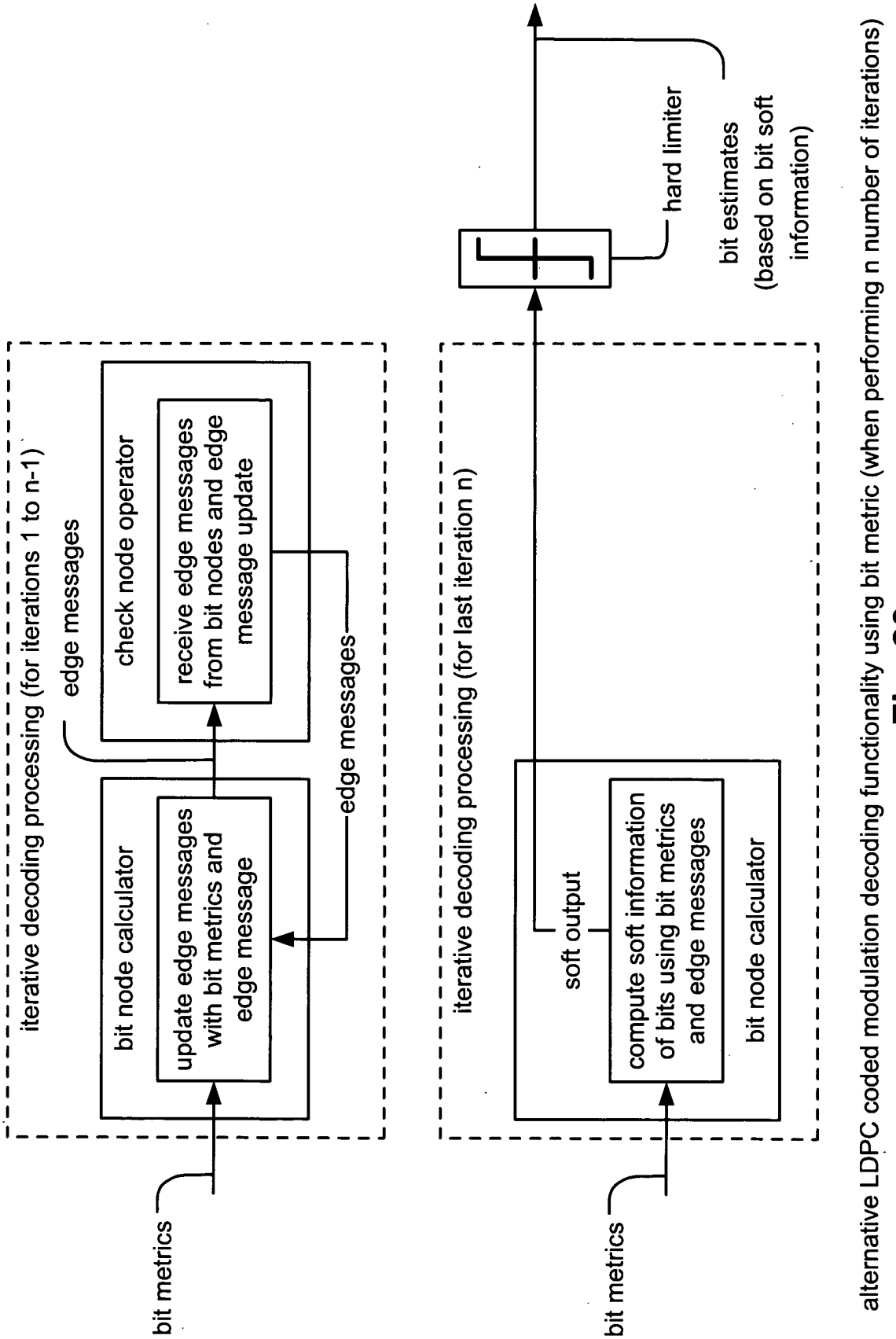


Fig. 20

alternative LDPC coded modulation decoding functionality using bit metric (when performing n number of iterations)

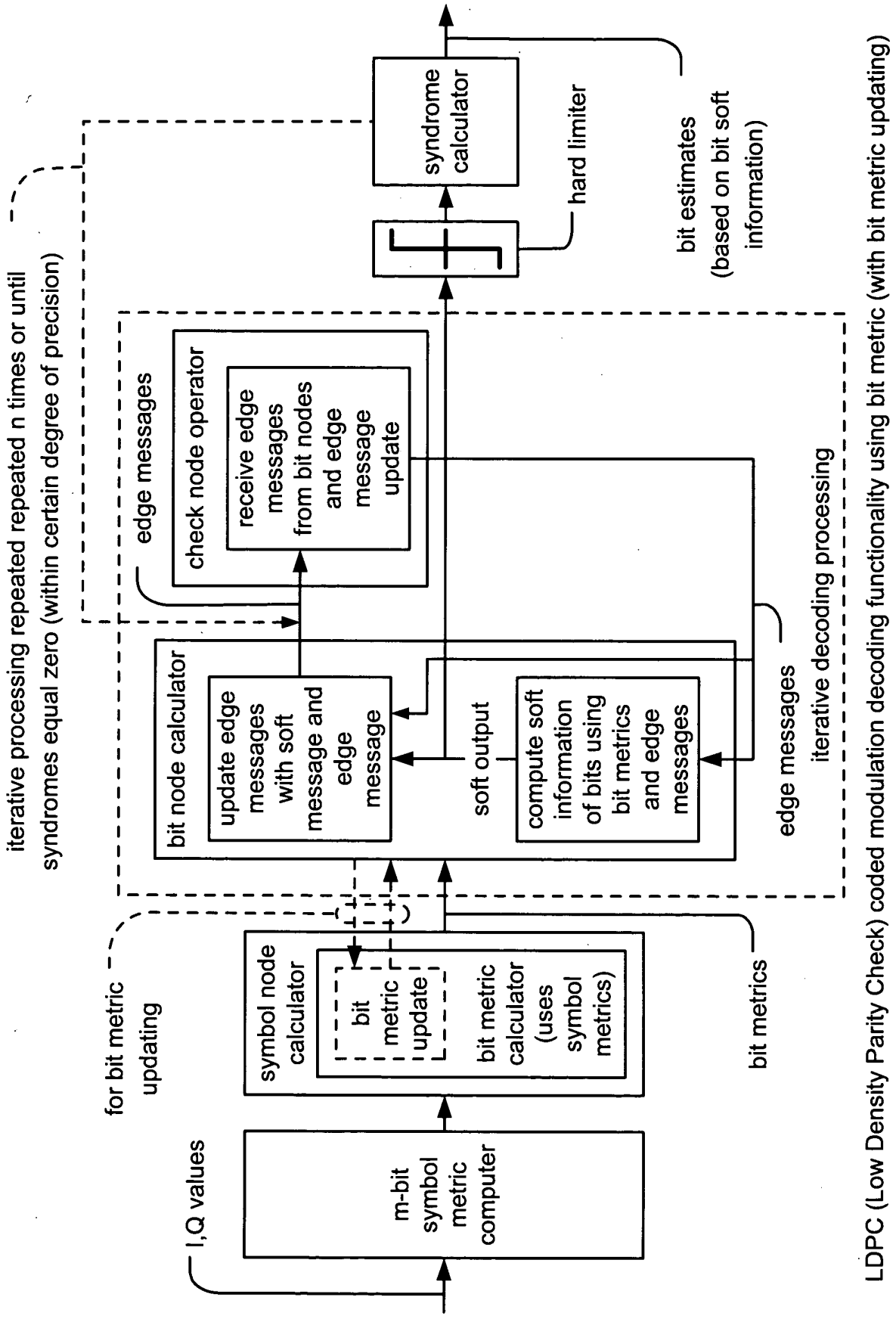
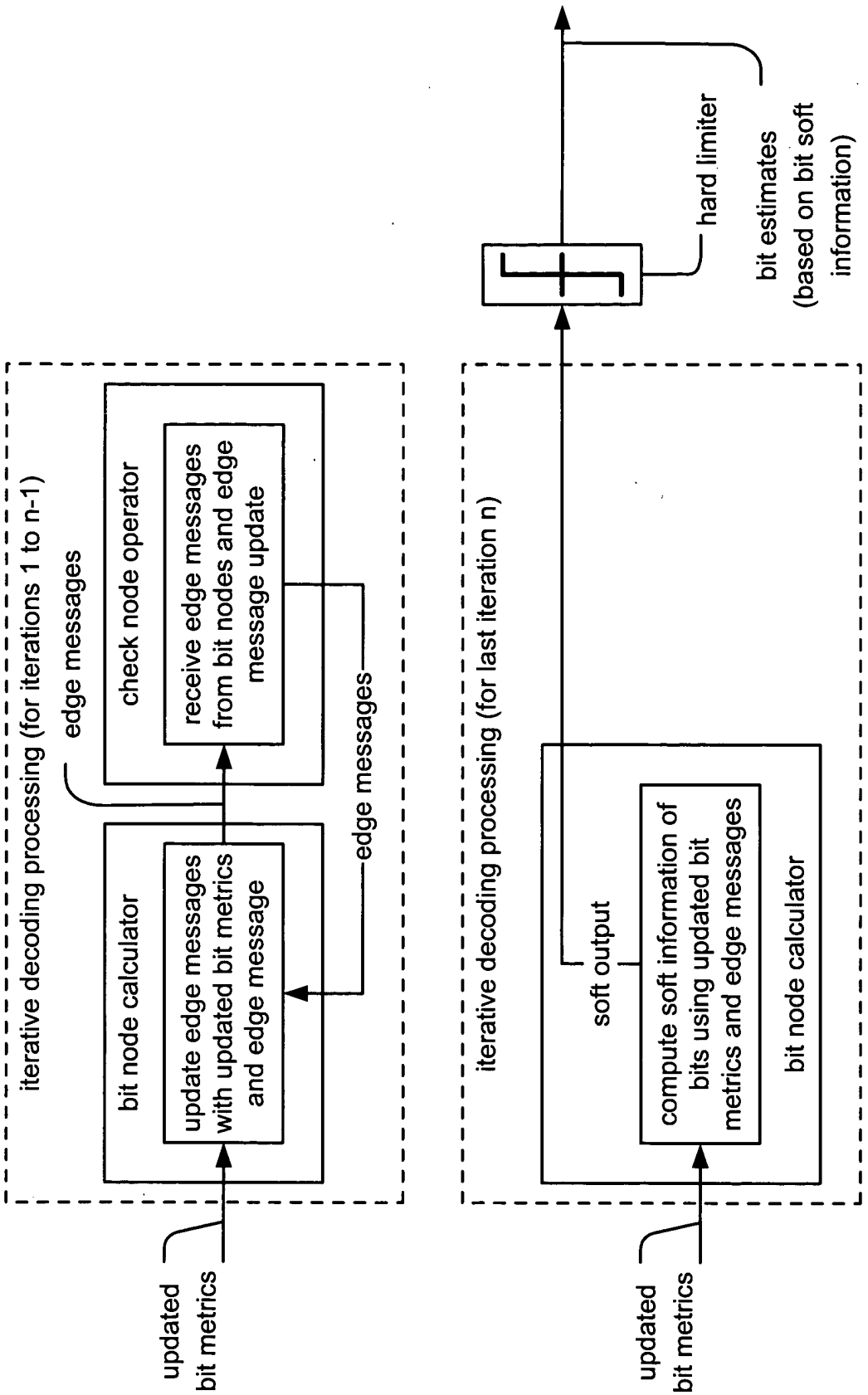
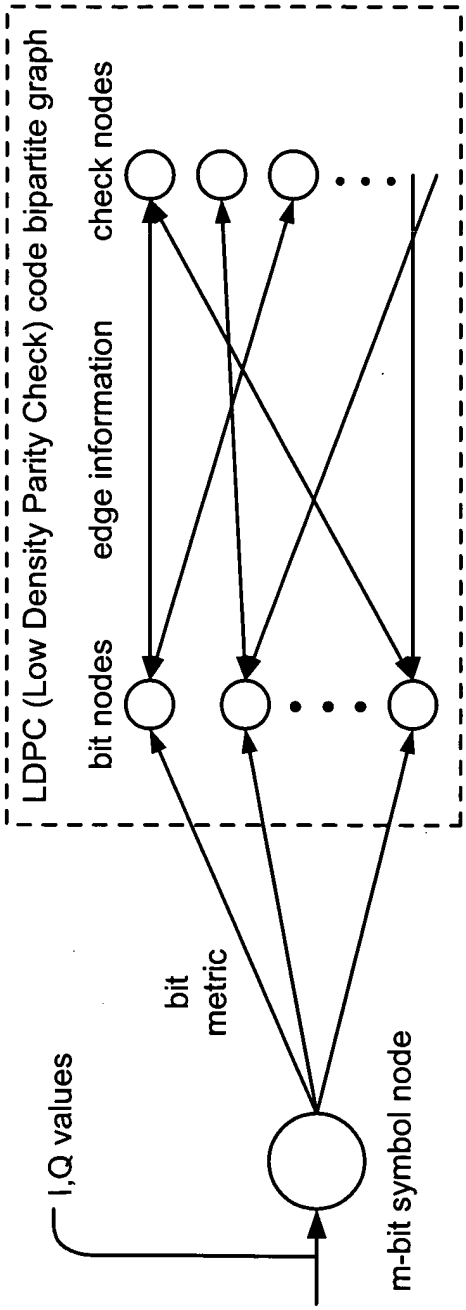

LDPC (Low Density Parity Check) coded modulation decoding functionality using bit metric (with bit metric updating)
iterative decoding processing
iterative processing repeated repeated n times or until syndromes equal zero (within certain degree of precision)
I,Q values
m-bit symbol metric computer
for bit metric updating
symbol node calculator
bit metric update
bit metric calculator (uses symbol metrics)
bit metrics
bit node calculator
update edge messages with soft message and edge message
soft output
compute soft information of bits using bit metrics and edge messages
edge messages
check node operator
receive edge messages from bit nodes and edge message update
edge messages
hard limiter
syndrome calculator
bit estimates (based on bit soft information)

Fig. 21



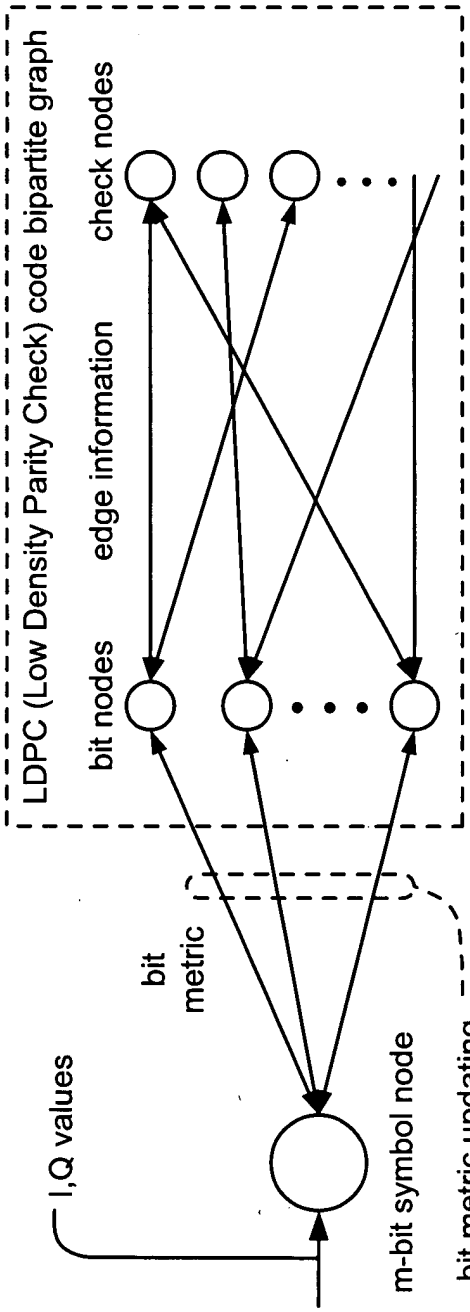
alternative LDPC coded modulation decoding functionality using bit metric (with bit metric updating) (when performing n number of iterations)

Fig. 22



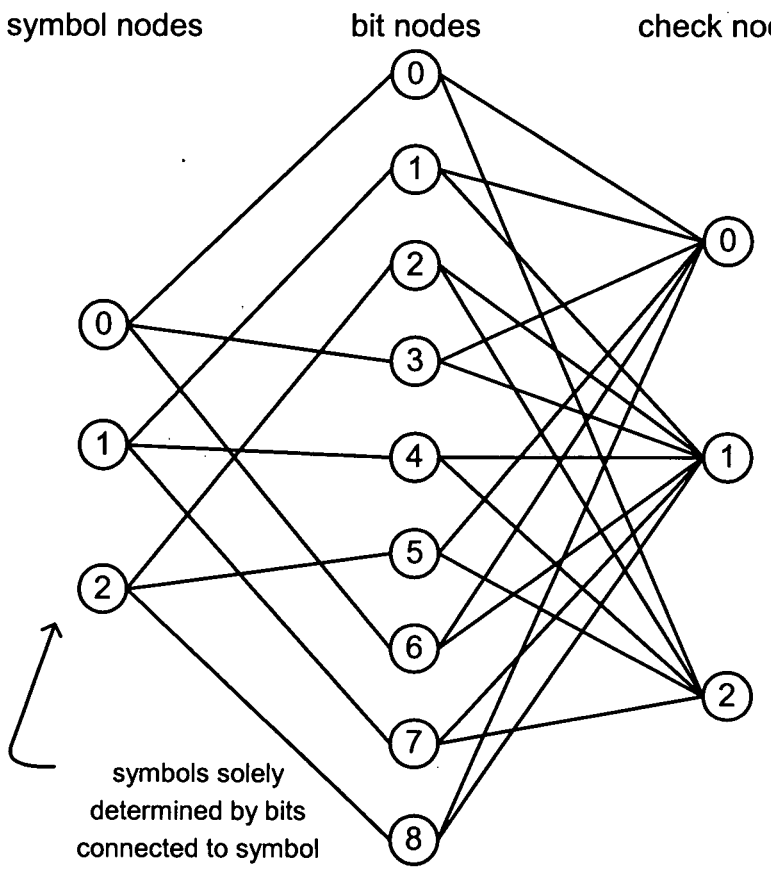
bit decoding using bit metric (shown with respect to LDPC code bipartite graph)

Fig. 23A



bit decoding using bit metric updating (shown with respect to LDPC code bipartite graph)

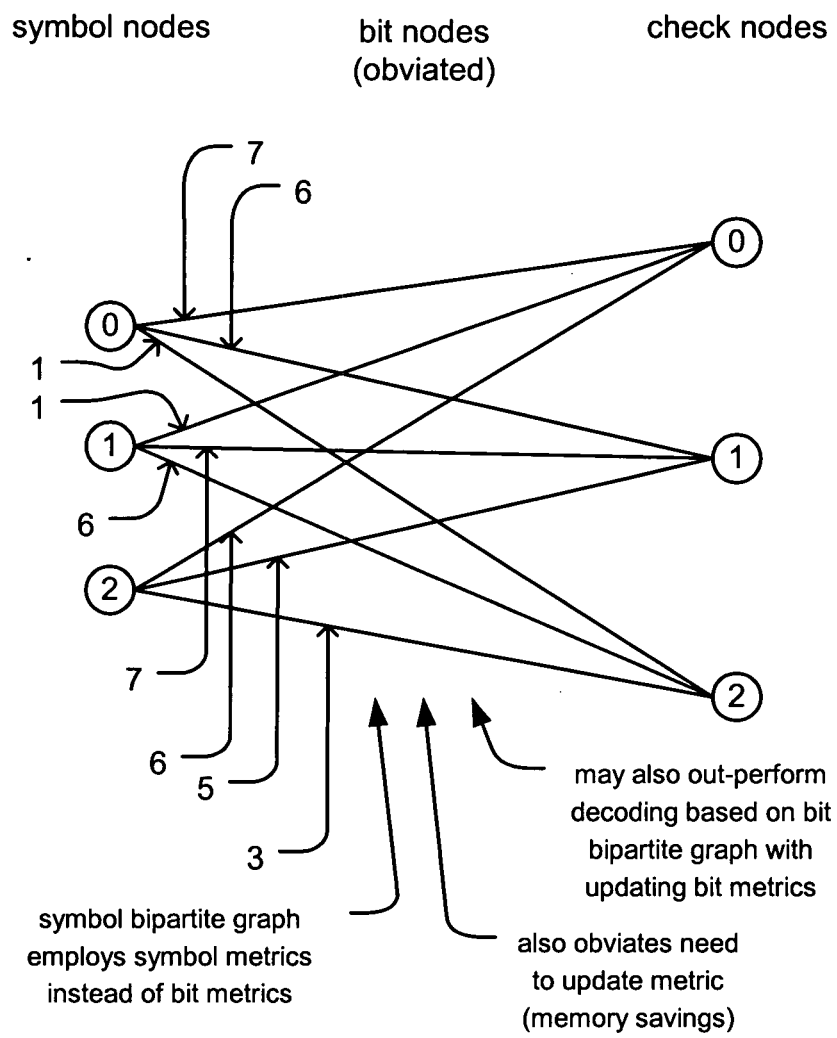
Fig. 23B



$$s_0 \leftrightarrow (b_0, b_3, b_6) \quad s_1 \leftrightarrow (b_1, b_4, b_7)$$
$$s_2 \leftrightarrow (b_2, b_5, b_8) \qquad \text{EQ 1}$$

LDPC (Low Density Parity Check) coded modulation tripartite graph (or bit bipartite graph) with symbol nodes connected to bit nodes

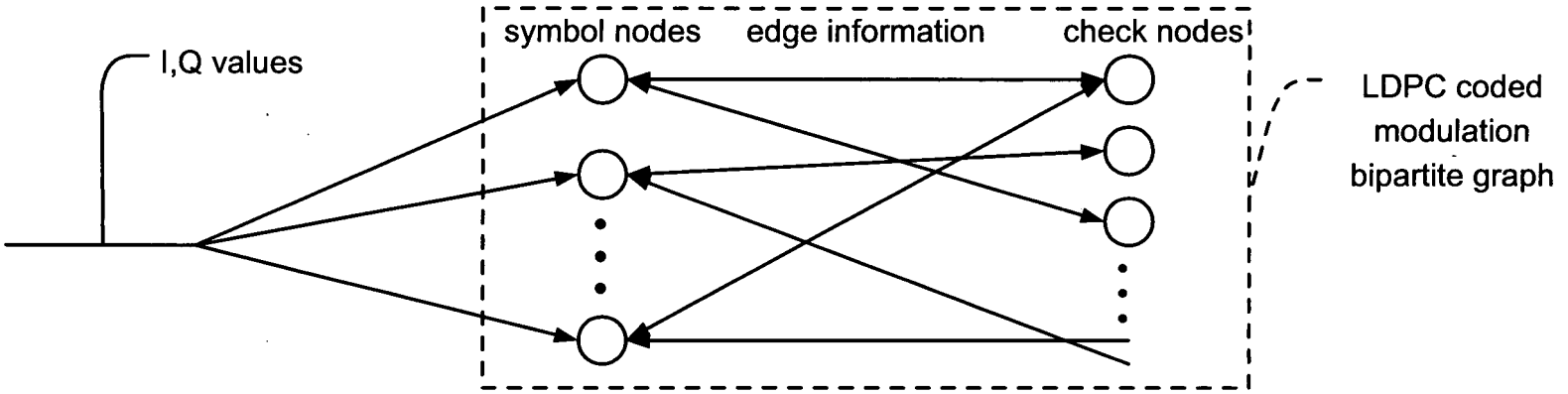
Fig. 24A



LDPC coded modulation bipartite graph (or symbol bipartite graph) with symbol nodes connected directly to check nodes (with labeled edges)

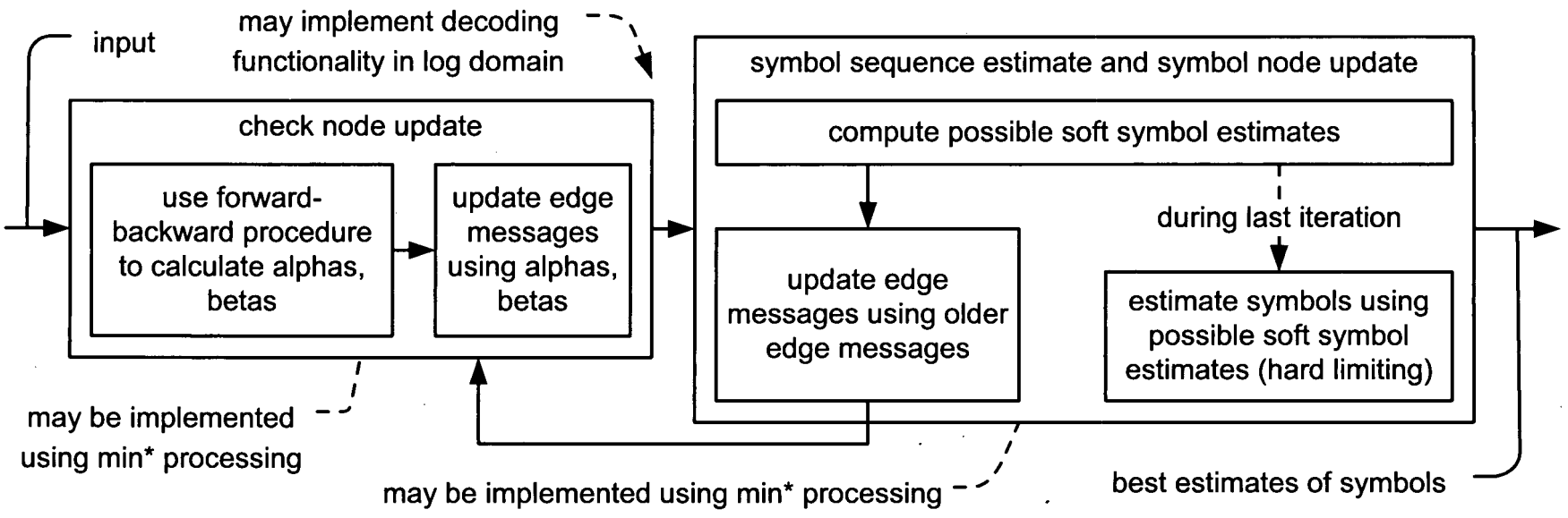
Fig. 24B

Docket No.
BP3134CIP



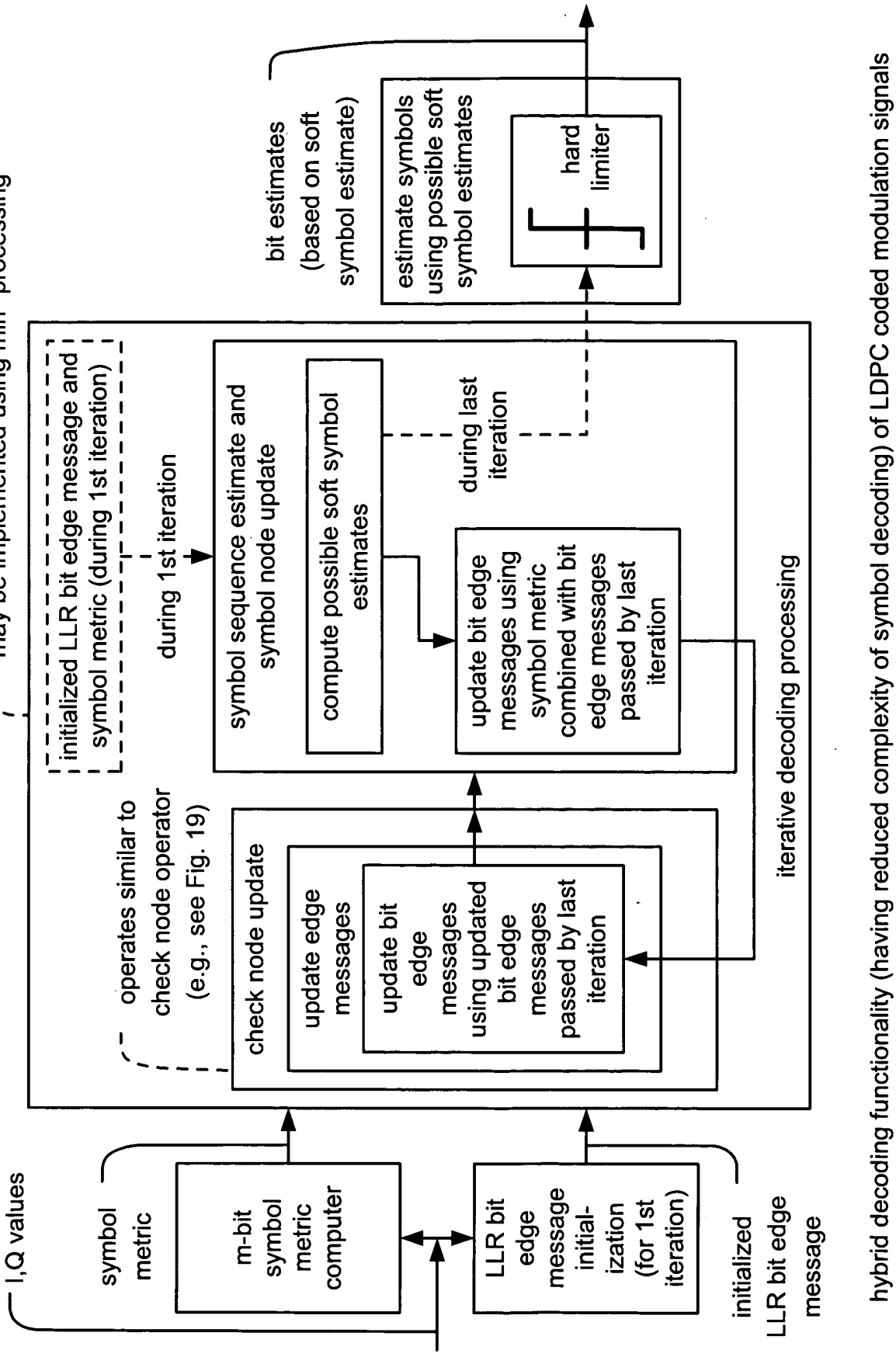
symbol decoding (shown with respect to LDPC (Low Density Parity Check) coded modulation bipartite graph)

Fig. 25A



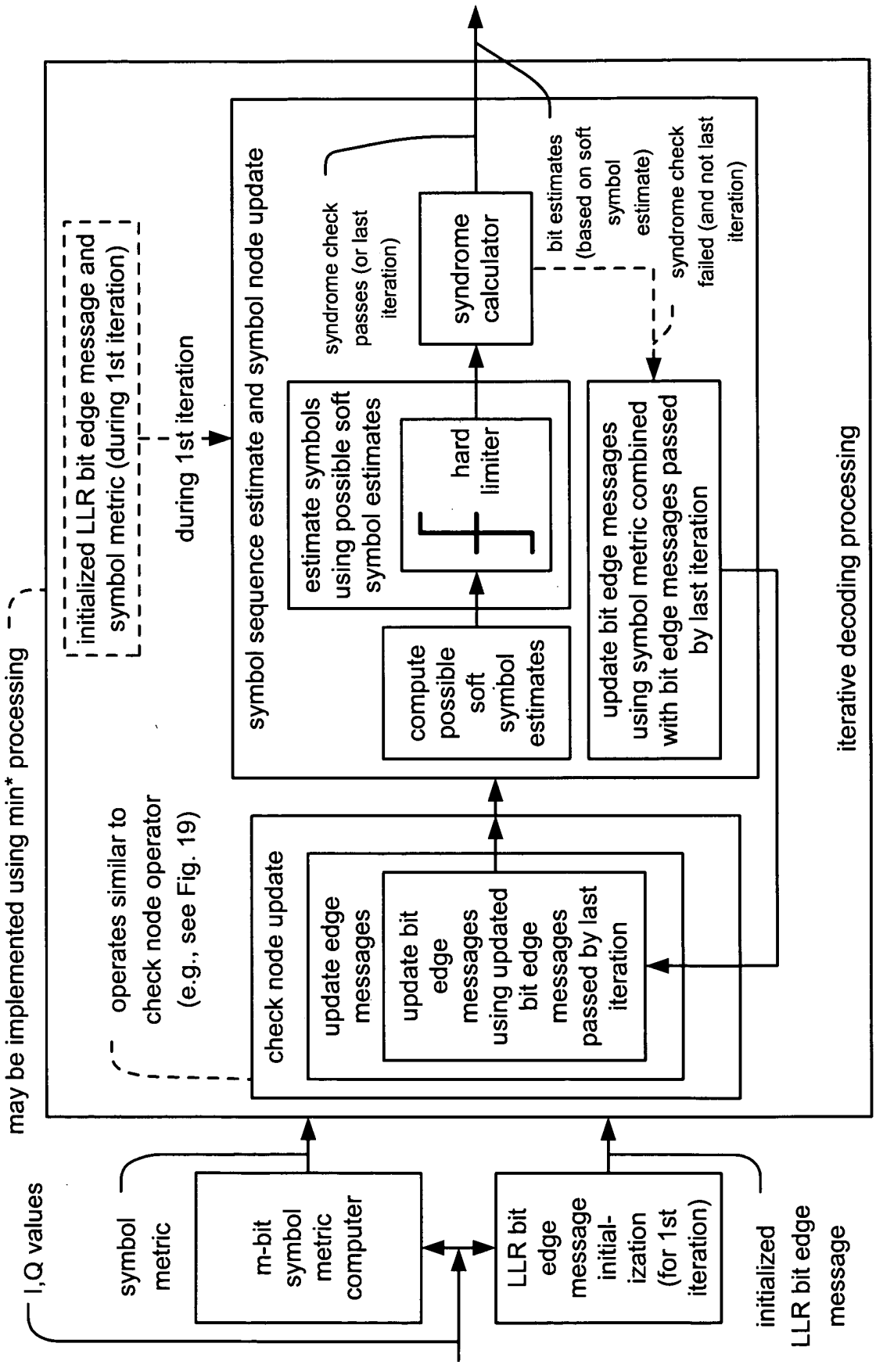
symbol decoding functionality (supported with LDPC (Low Density Parity Check) coded modulation bipartite graph)

Fig. 25B



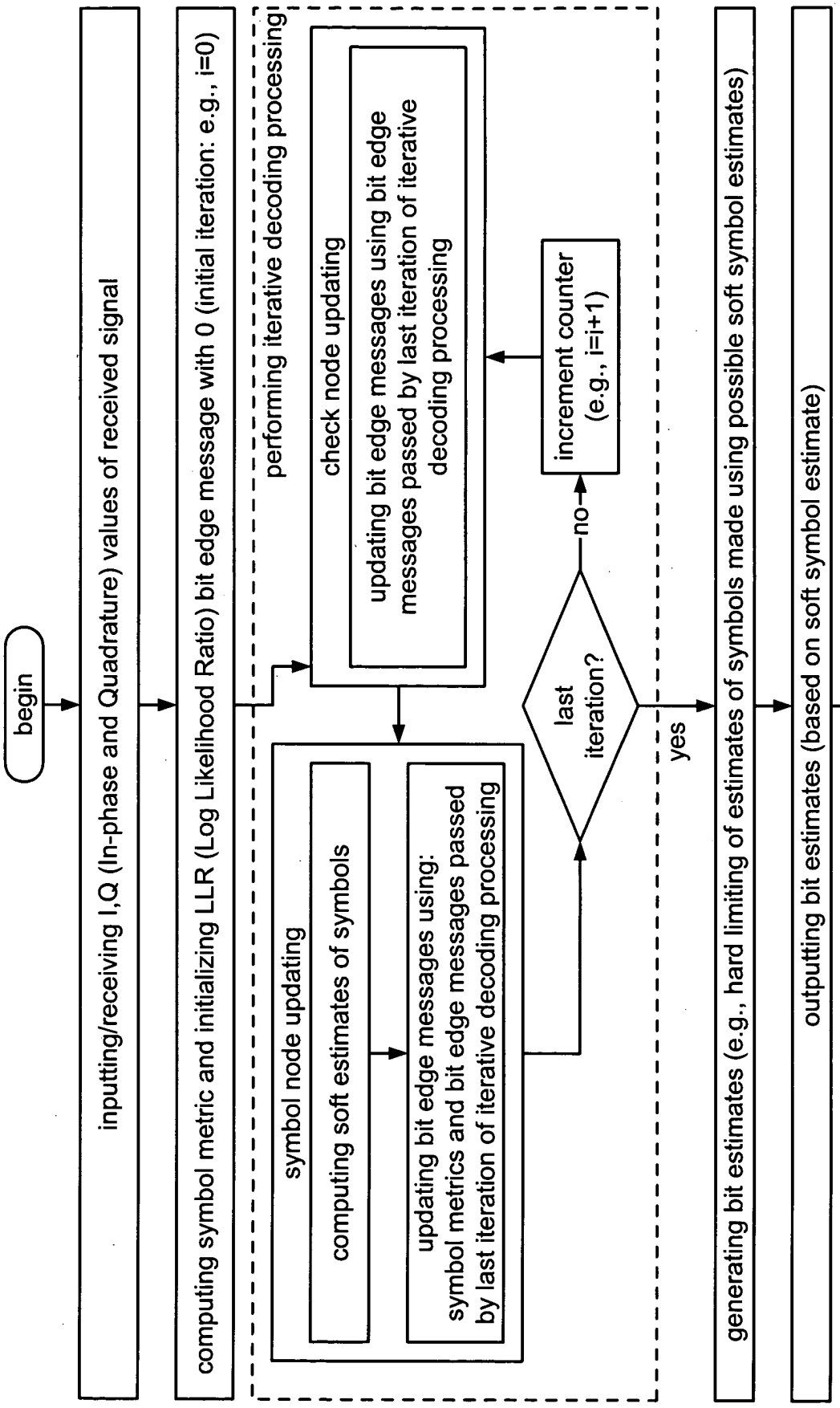
hybrid decoding functionality (having reduced complexity of symbol decoding) of LDPC coded modulation signals

Fig. 26



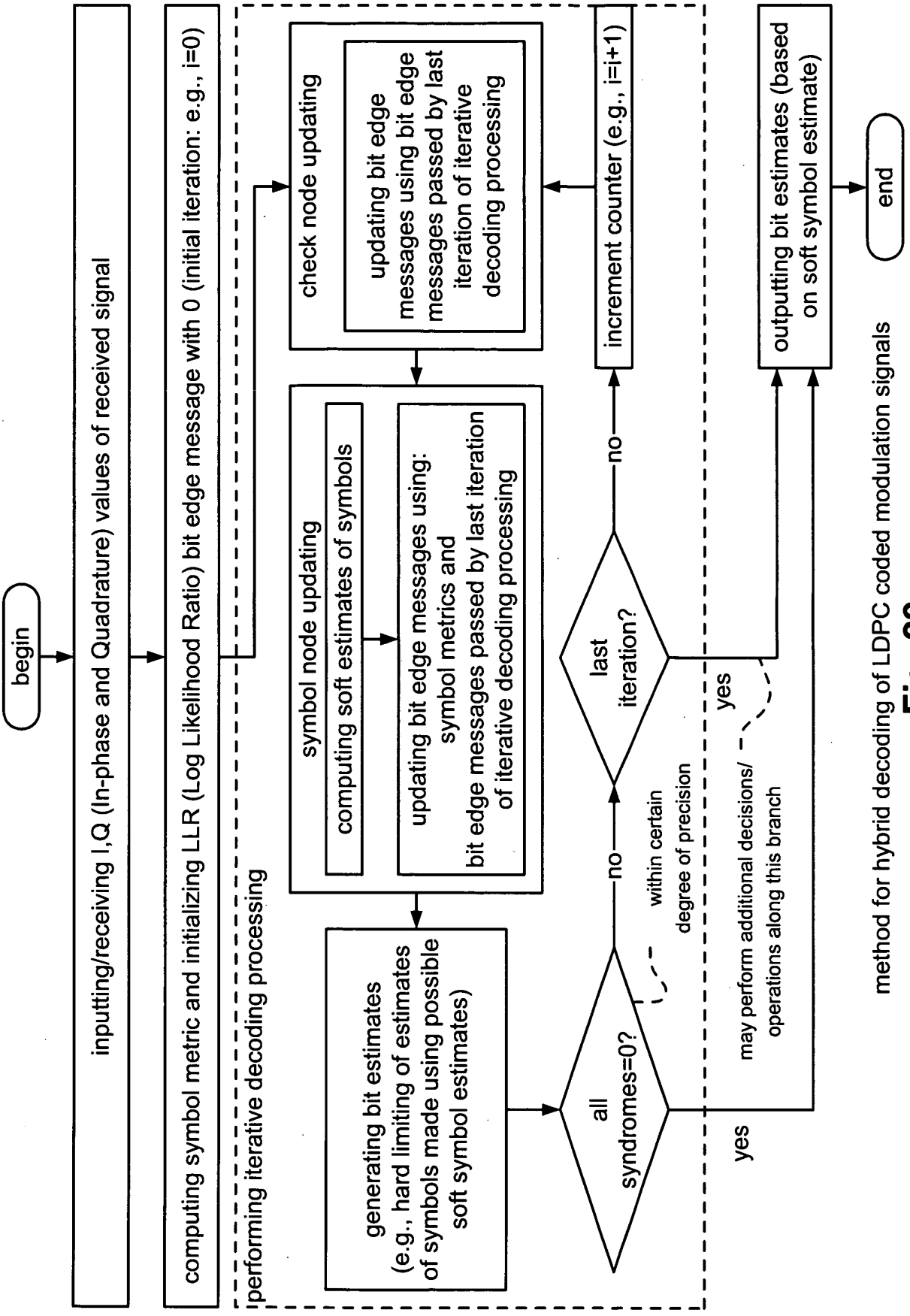
hybrid decoding functionality (having reduced complexity of symbol decoding) of LDPC coded modulation signals

Fig. 27



method for hybrid decoding of LDPC coded modulation signals

Fig. 28



method for hybrid decoding of LDPC coded modulation signals

Fig. 29

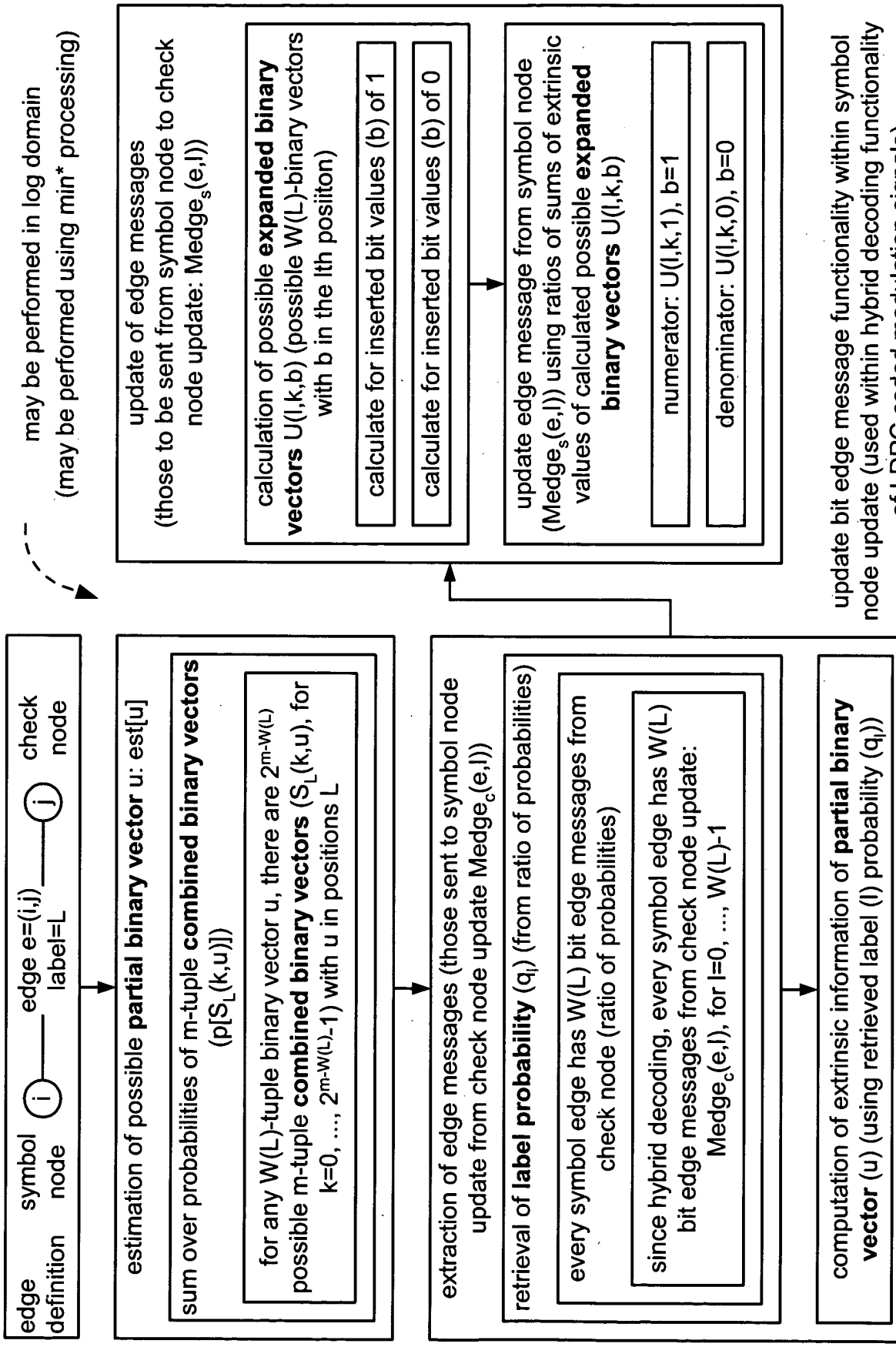
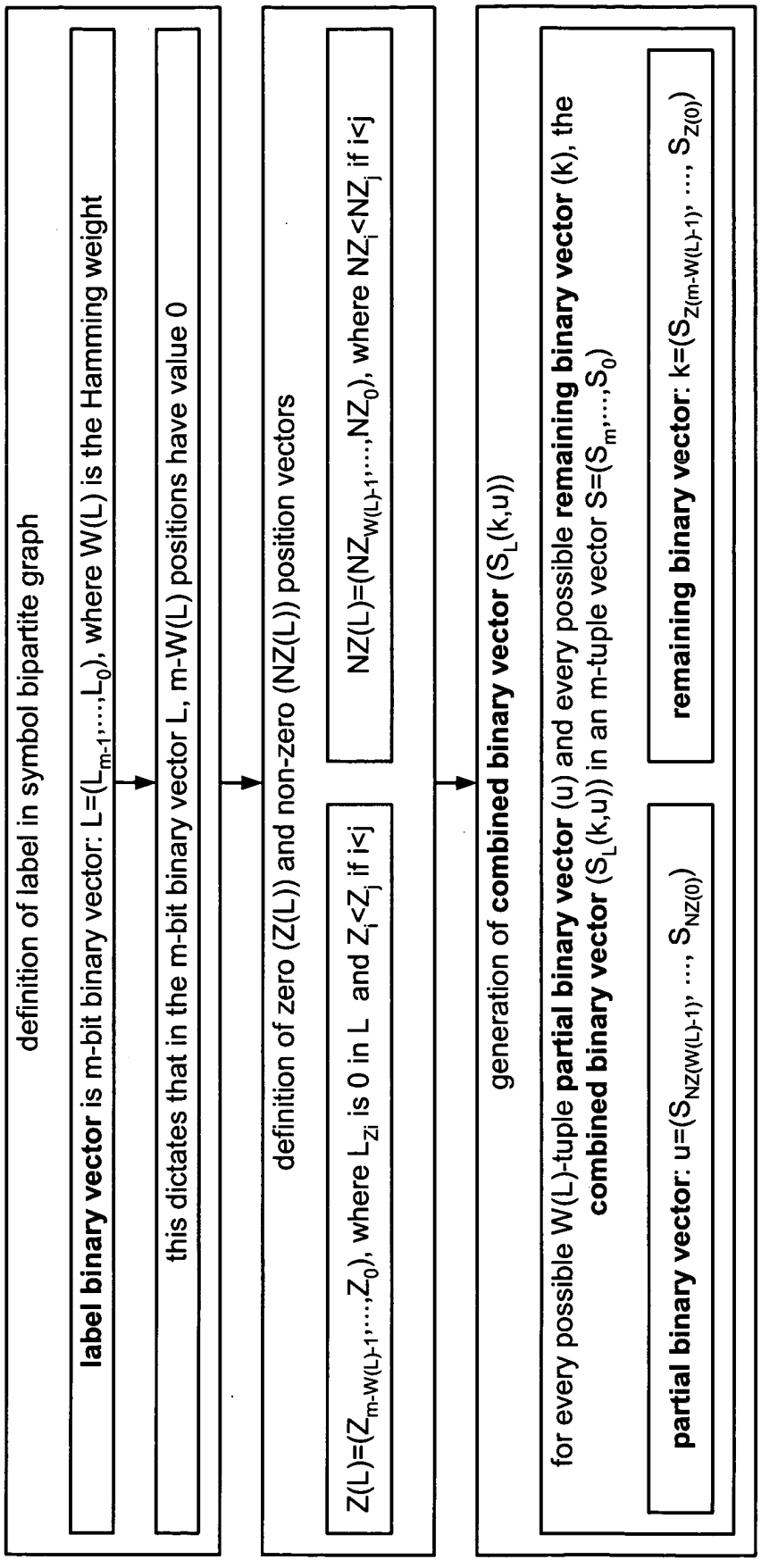
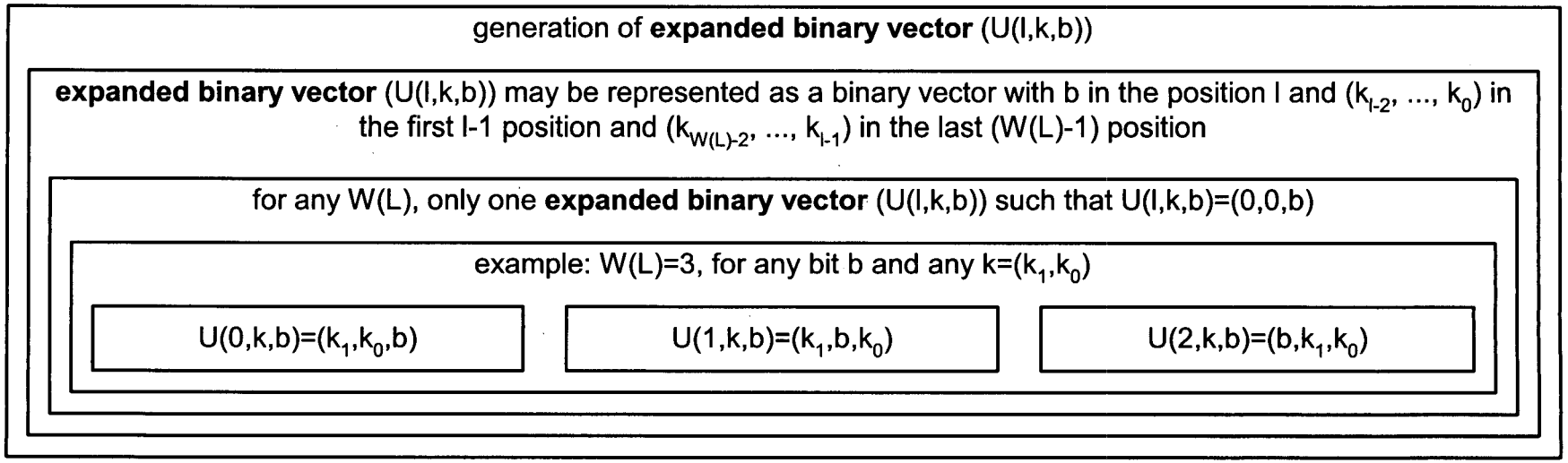

edge definition
symbol node
i
edge e=(i,j) label=L
j
check node
may be performed in log domain (may be performed using min* processing)
estimation of possible **partial binary vector** u: est[u]
sum over probabilities of m-tuple **combined binary vectors** (p[S_L(k,u)])
for any W(L)-tuple binary vector u, there are 2^m-W(L) possible m-tuple **combined binary vectors** (S_L(k,u), for k=0, ..., 2^m-W(L)-1) with u in positions L
extraction of edge messages (those sent to symbol node update from check node update Medge_c(e,l))
retrieval of **label probability** (q_l) (from ratio of probabilities)
every symbol edge has W(L) bit edge messages from check node (ratio of probabilities)
since hybrid decoding, every symbol edge has W(L) bit edge messages from check node update: Medge_c(e,l), for l=0, ..., W(L)-1
computation of extrinsic information of **partial binary vector** (u) (using retrieved label (l) probability (q_l))
update of edge messages (those to be sent from symbol node to check node update: Medge_s(e,l))
calculation of possible **expanded binary vectors** U(l,k,b) (possible W(L)-binary vectors with b in the lth posiiton)
calculate for inserted bit values (b) of 1
calculate for inserted bit values (b) of 0
update edge message from symbol node (Medge_s(e,l)) using ratios of sums of extrinsic values of calculated possible **expanded binary vectors** U(l,k,b)
numerator: U(l,k,1), b=1
denominator: U(l,k,0), b=0
update bit edge message functionality within symbol node update (used within hybrid decoding functionality of LDPC coded modulation signals)

Fig. 30



combined binary vector generation

Fig. 31



expanded binary vector generation

Fig. 32

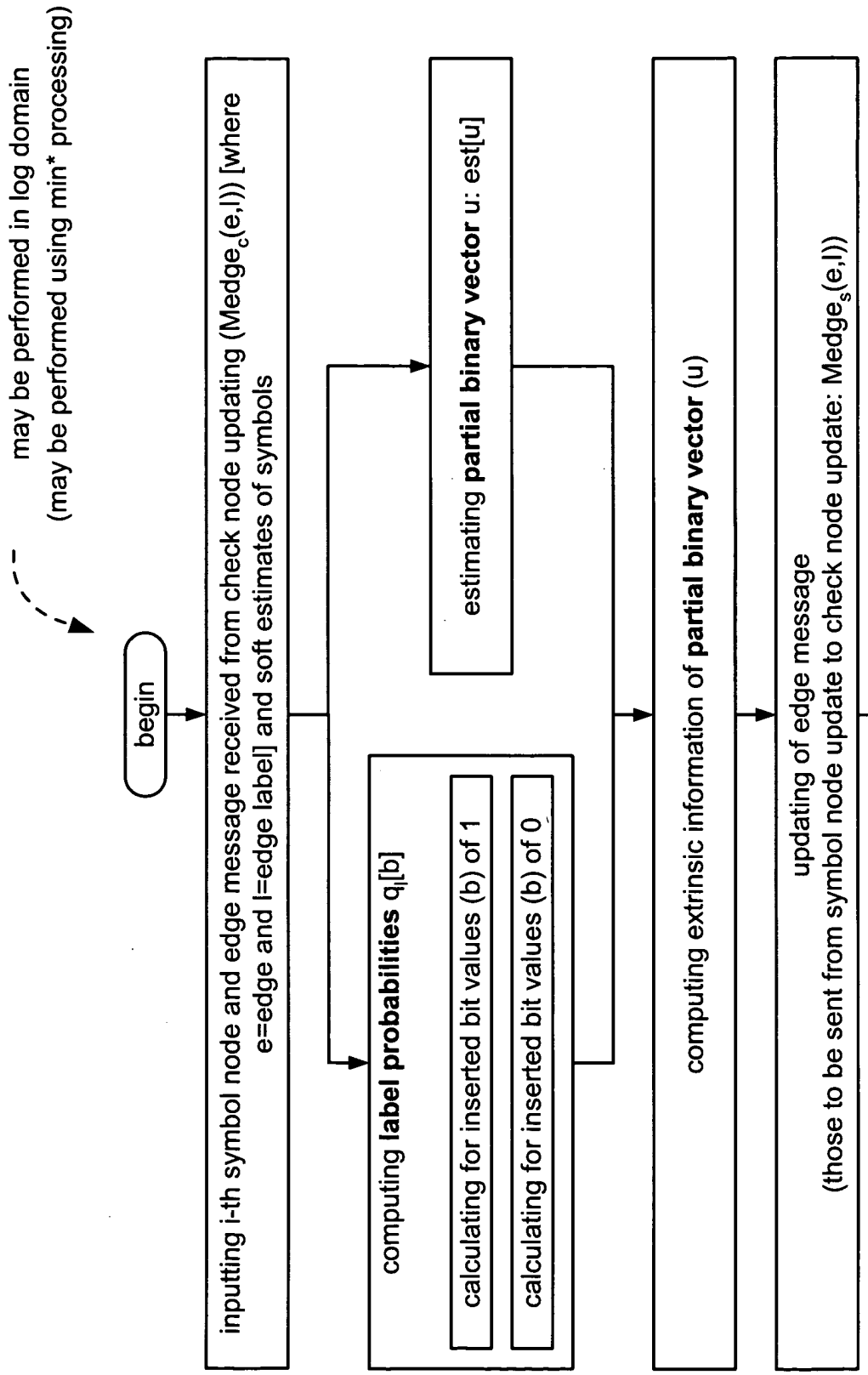
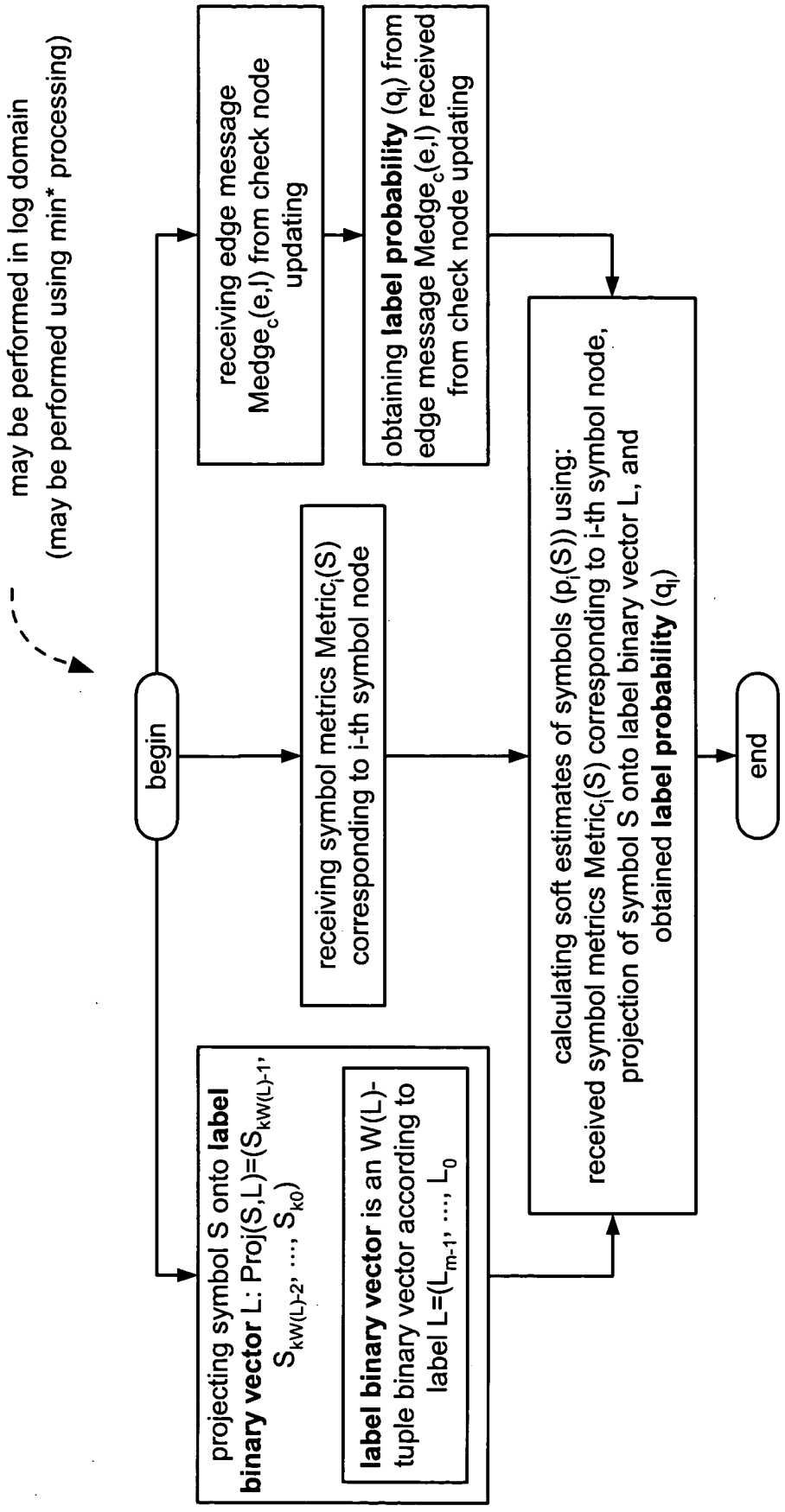


Fig. 33

method for updating edge messages (within symbol node updating)



method for calculating soft estimates of symbols (within symbol node updating)

Fig. 34

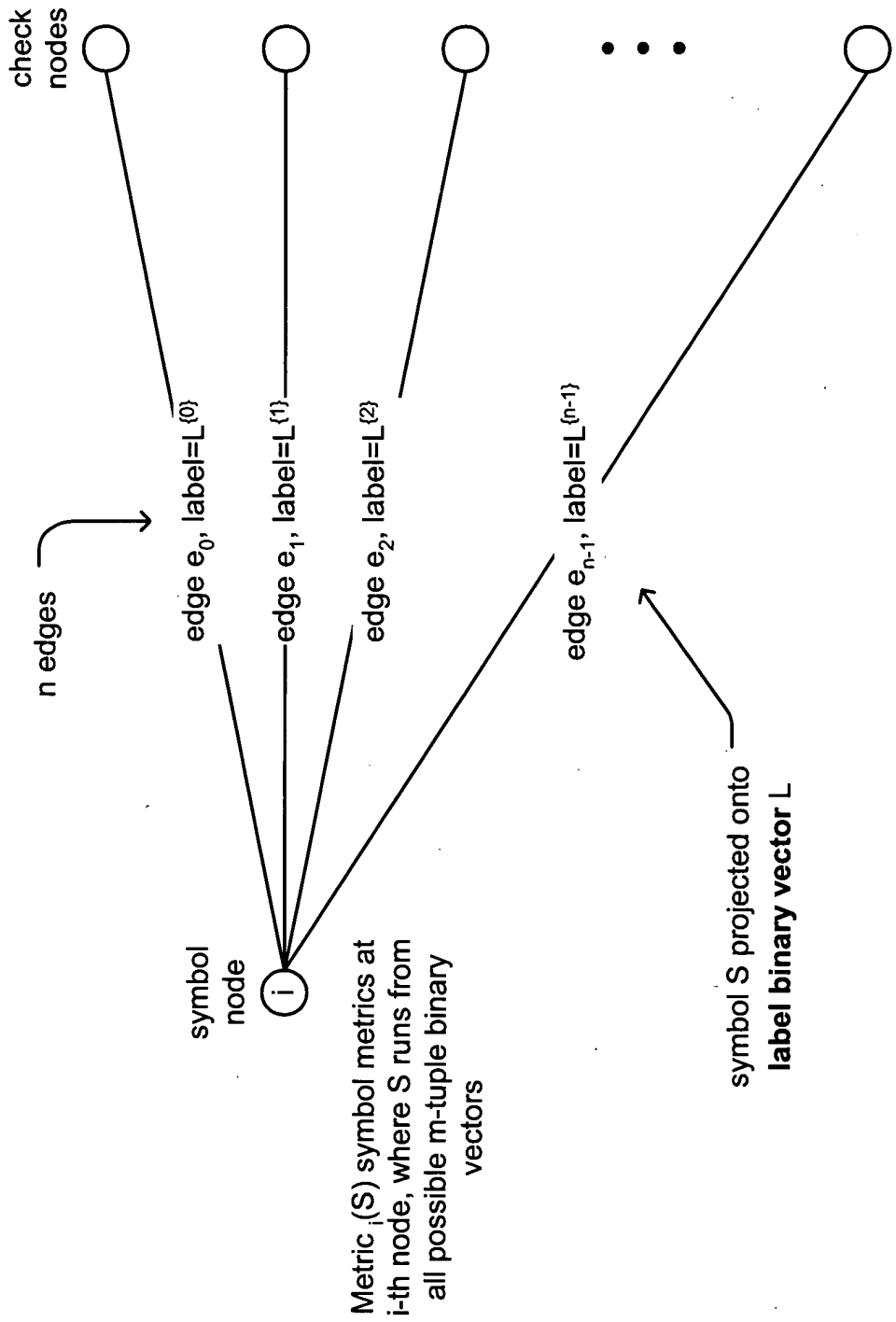

check nodes
n edges
edge e_0, label=$L^{\{0\}}$
edge e_1, label=$L^{\{1\}}$
edge e_2, label=$L^{\{2\}}$
edge e_{n-1}, label=$L^{\{n-1\}}$
symbol node
i
Metric$_i$(S) symbol metrics at i-th node, where S runs from all possible m-tuple binary vectors
symbol S projected onto **label binary vector** L
projection of symbol onto label binary vector

Fig. 35

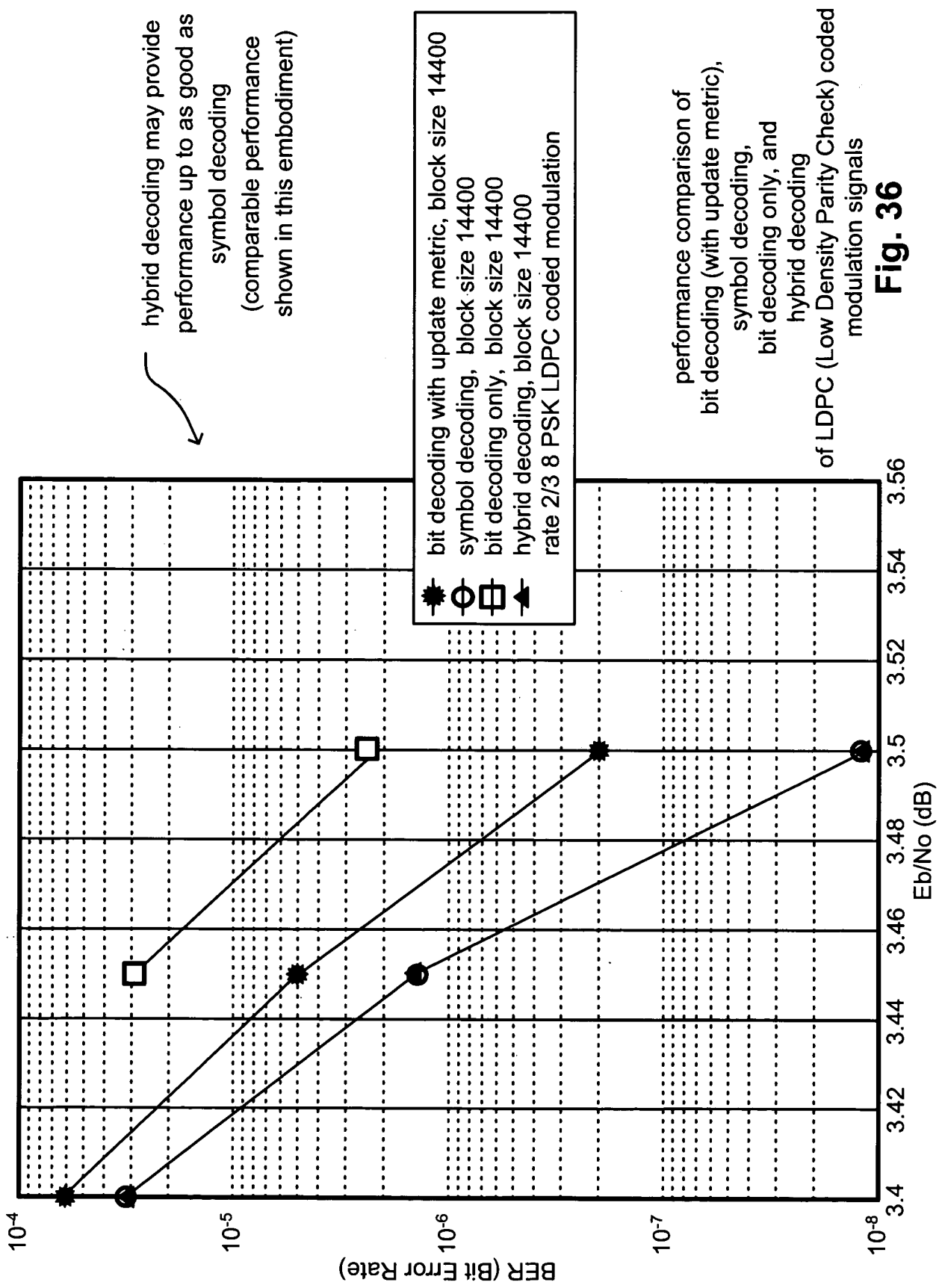
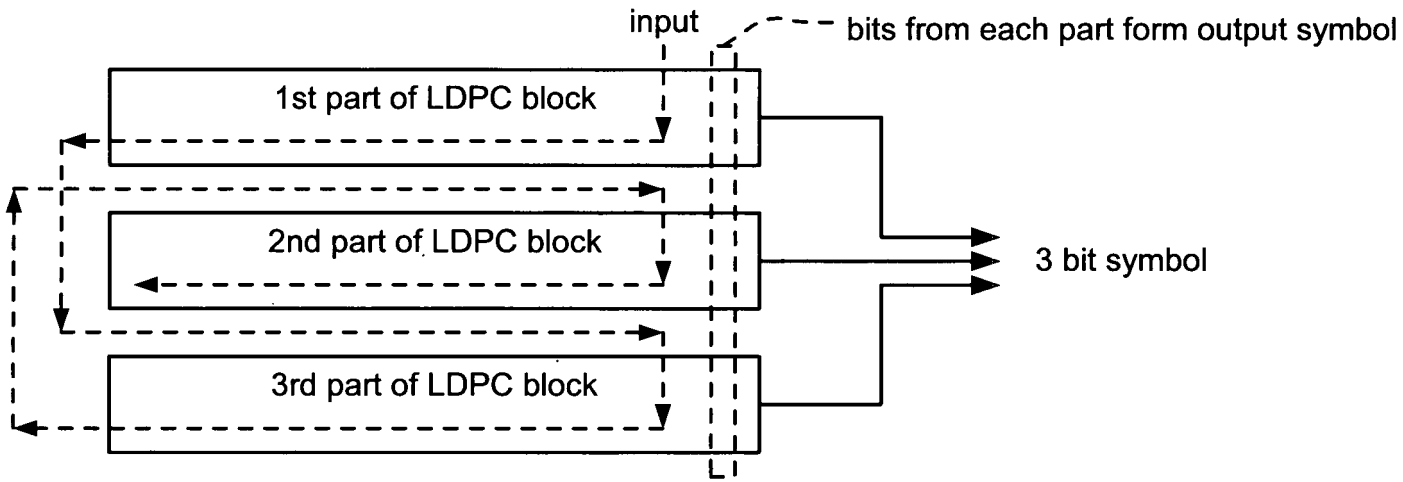
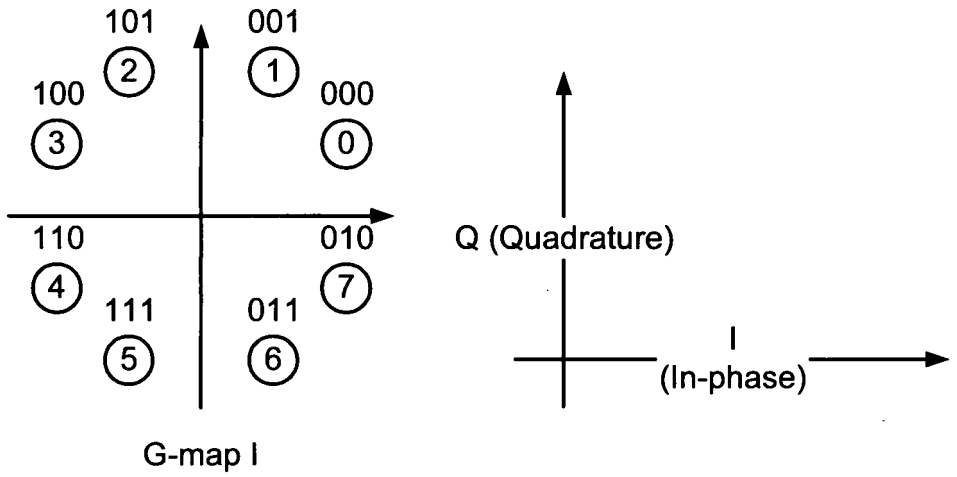

hybrid decoding may provide performance up to as good as symbol decoding (comparable performance shown in this embodiment)
bit decoding with update metric, block size 14400 symbol decoding, block size 14400
bit decoding only, block size 14400
hybrid decoding, block size 14400
rate 2/3 8 PSK LDPC coded modulation
performance comparison of bit decoding (with update metric), symbol decoding, bit decoding only, and hybrid decoding of LDPC (Low Density Parity Check) coded modulation signals
BER (Bit Error Rate)
Eb/No (dB)
10-4
10-5
10-6
10-7
10-8
3.4
3.42
3.44
3.46
3.48
3.5
3.52
3.54
3.56

Fig. 36



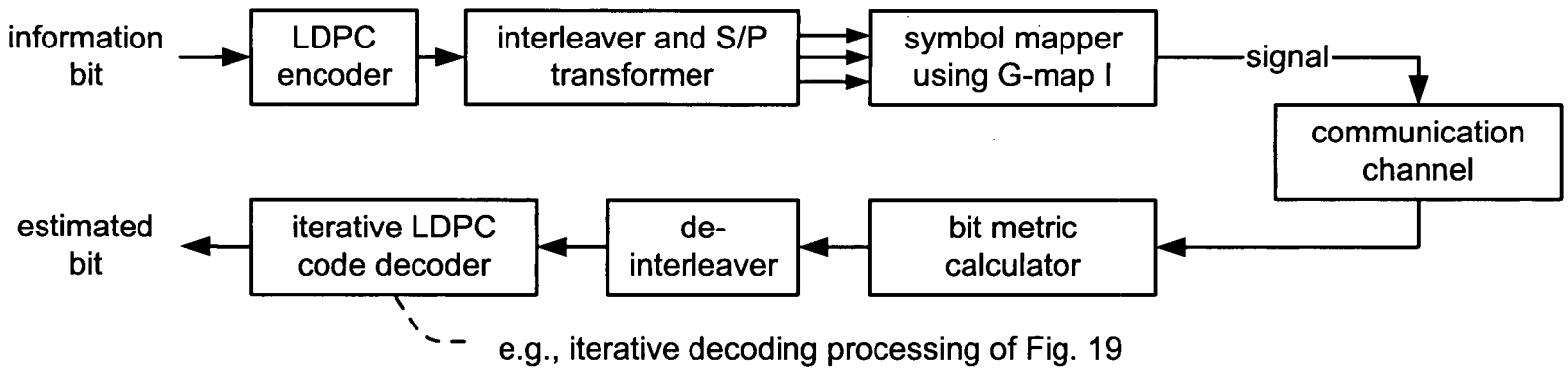
interleaver and S/P (Serial to Parallel) transformer as performed within an LDPC-BICM system

Fig. 37A



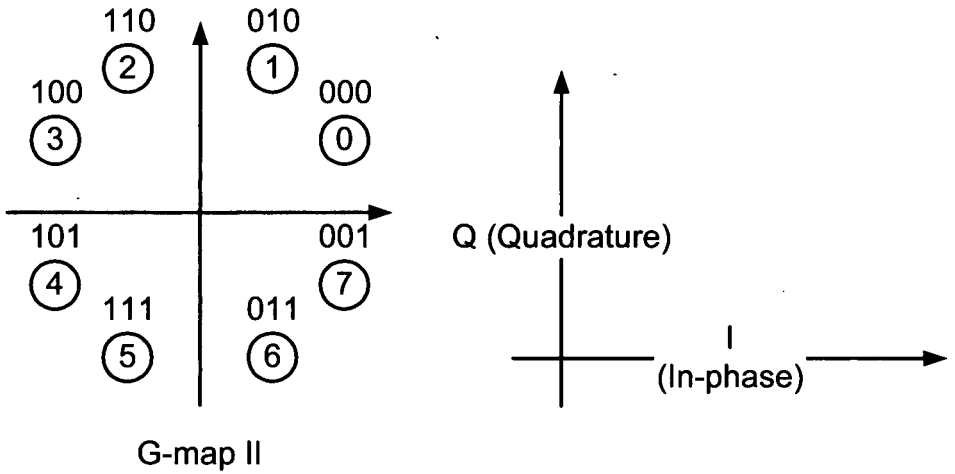
G-map I (Gray code map) (shown using 8 PSK shaped constellation)

Fig. 37B



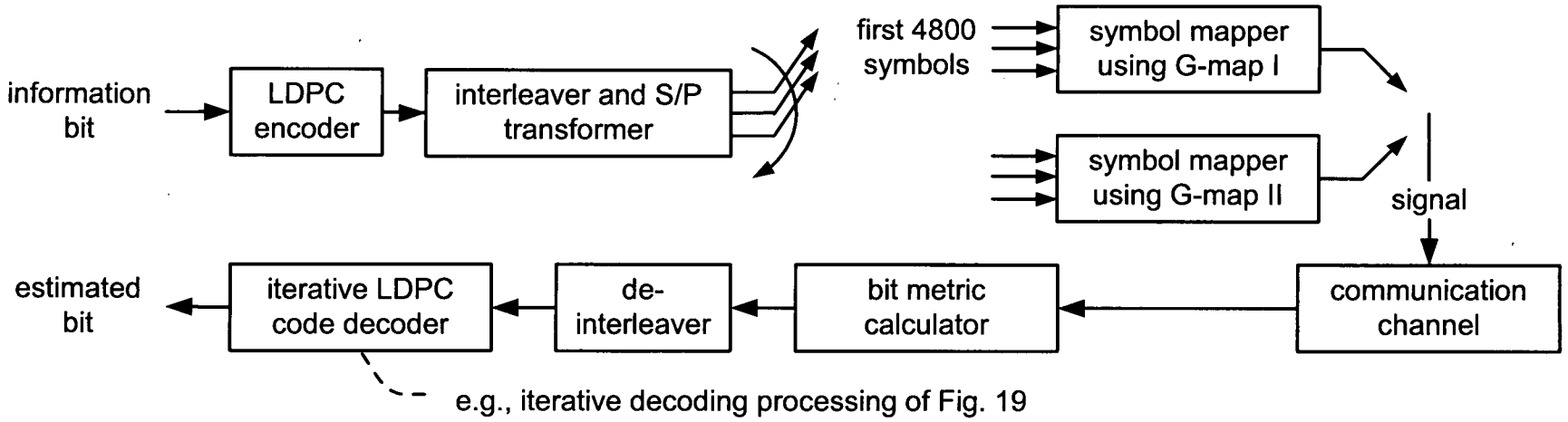
LDPC-BICM communication system I (encoding using single Gray code map and decoding using bit metric only)

Fig. 38A



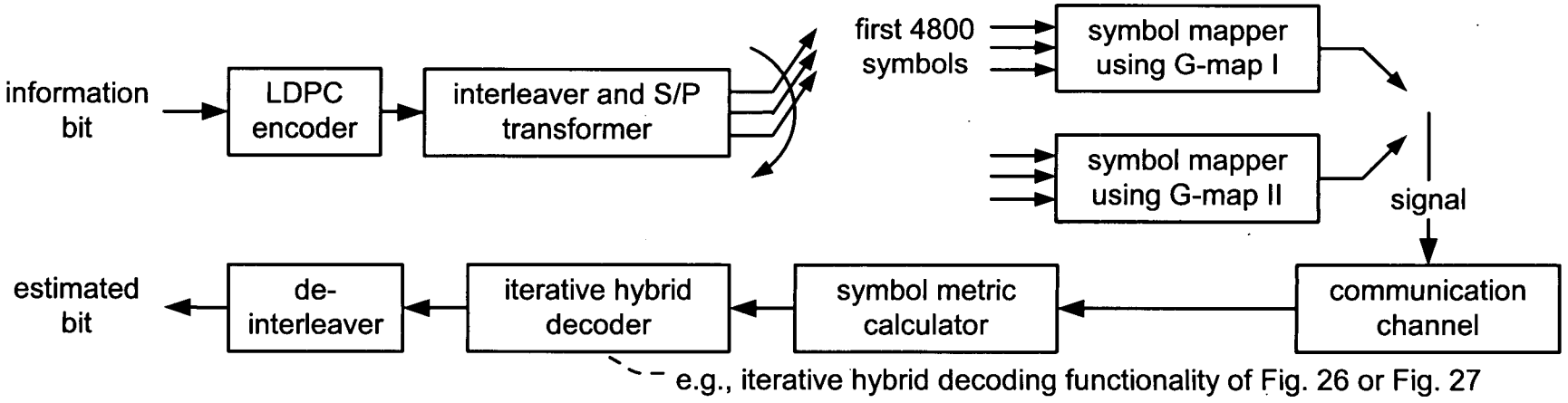
G-map II (Gray code map) (shown using 8 PSK shaped constellation)

Fig. 38B



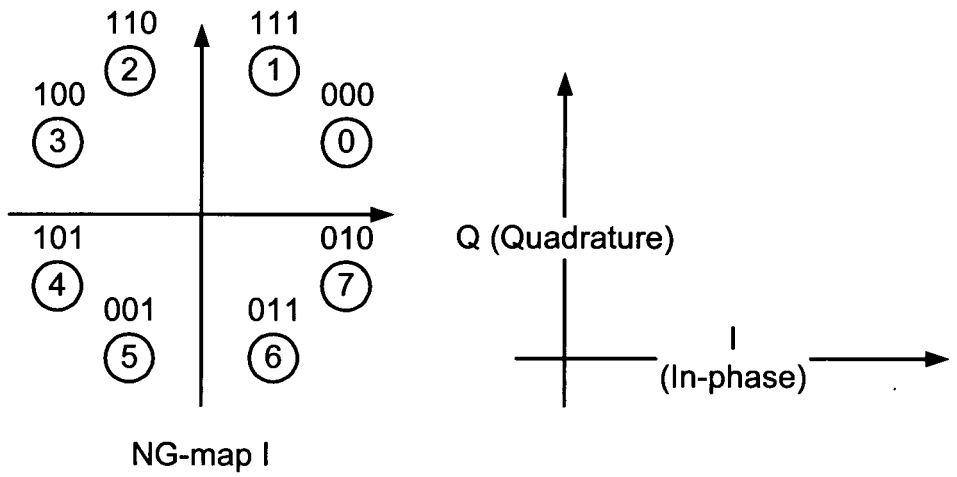
LDPC-BICM communication system II (encoding using 2 Gray code maps and decoding using bit metric only)

Fig. 39A



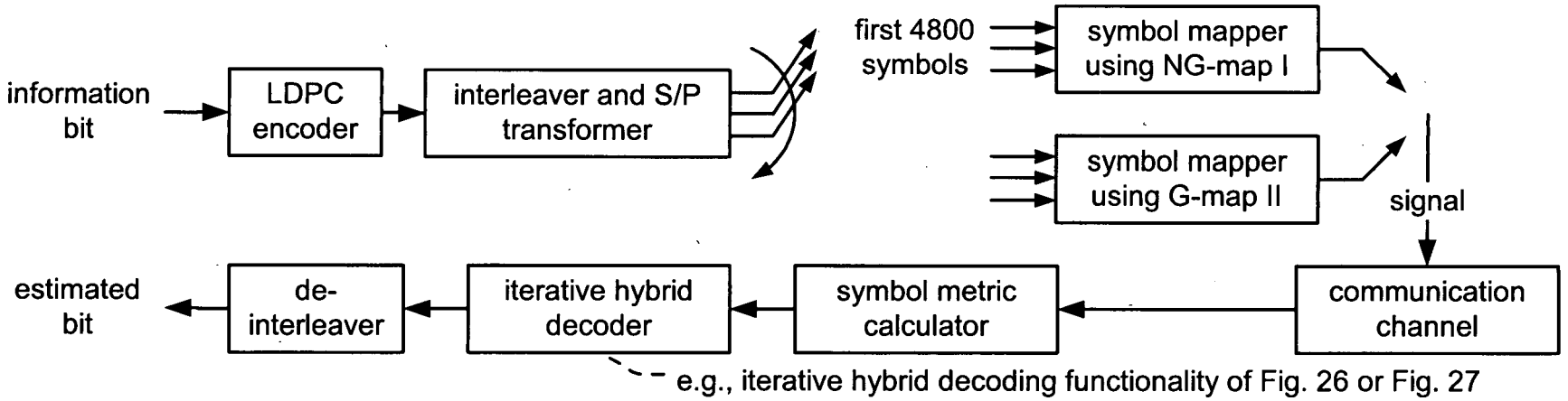
LDPC-BICM communication system III (encoding using 2 Gray code maps and decoding using hybrid decoding approach)

Fig. 39B



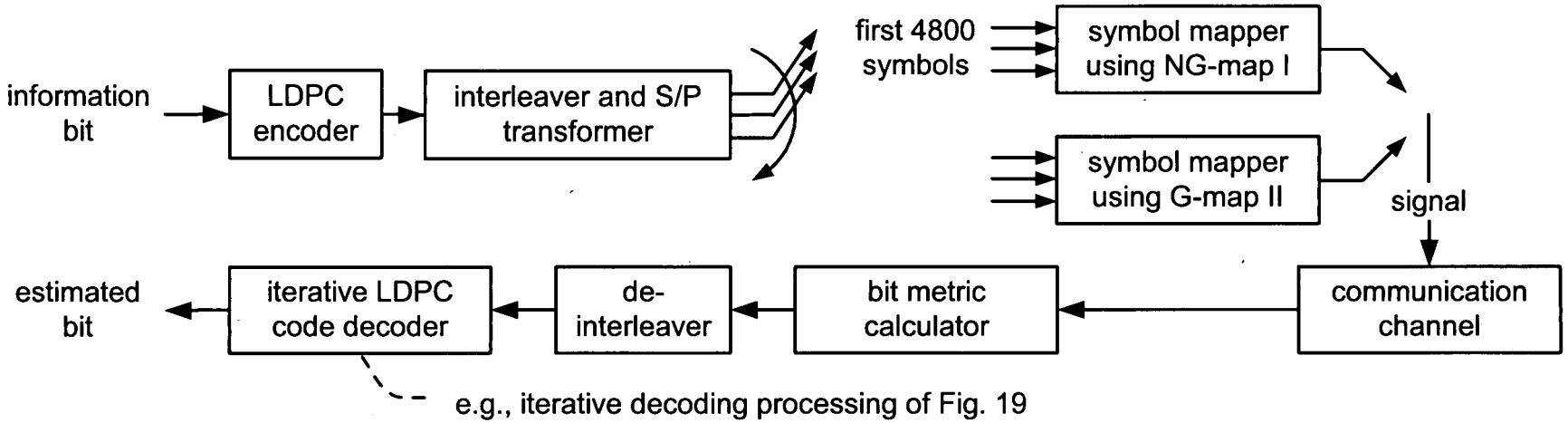
NG-map I (non-Gray code map) (shown using 8 PSK shaped constellation)

Fig. 40A



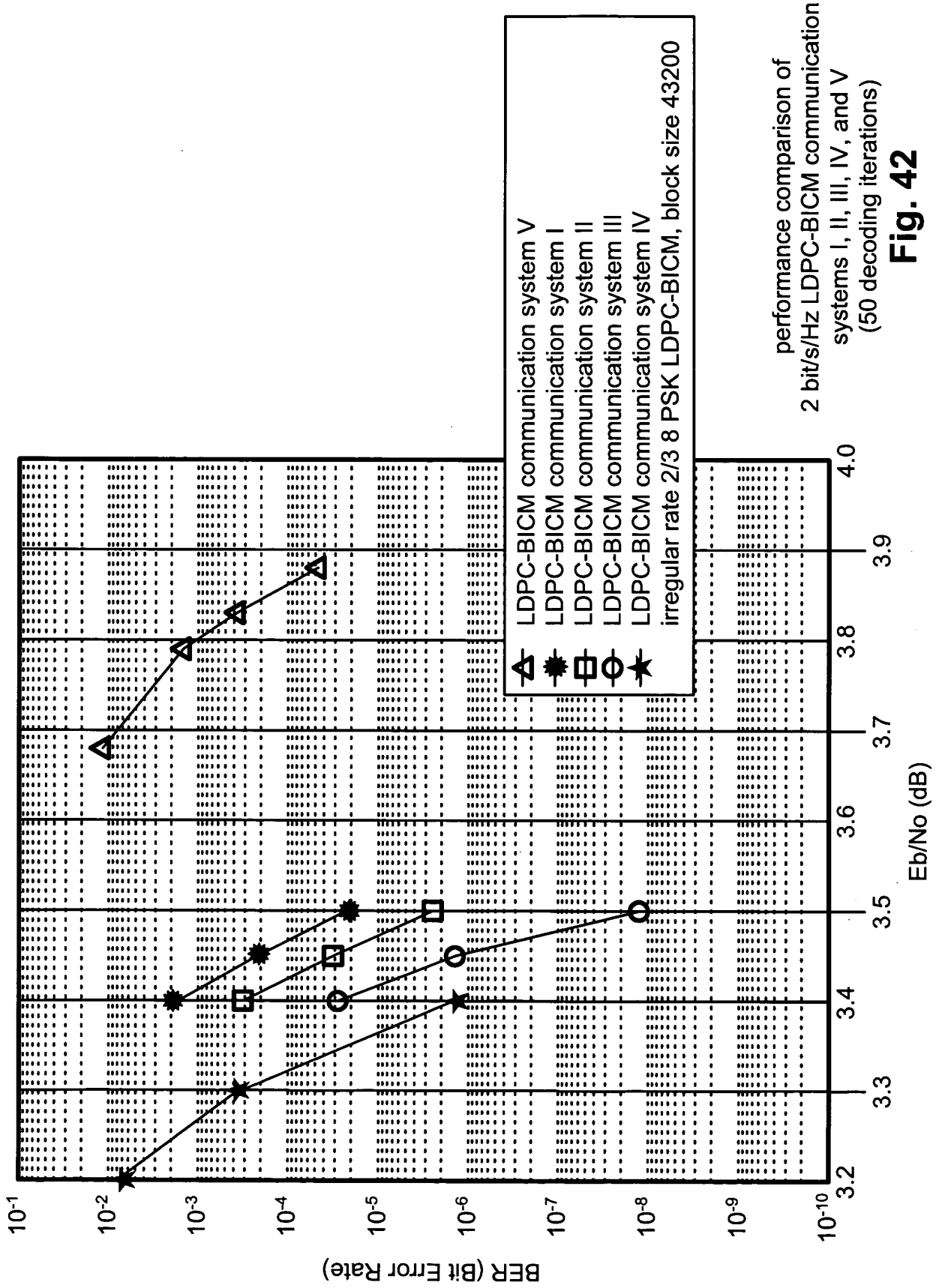
LDPC-BICM communication system IV using NG-map I (encoding using 1 Gray code map, 1 non-Gray code map and decoding using hybrid decoding approach)

Fig. 40B



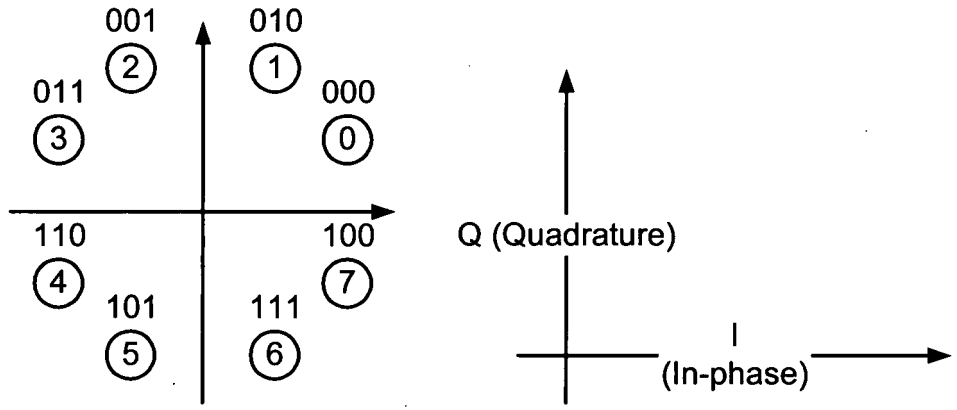
LDPC-BICM communication system V (encoding using 1 Gray code map, 1 non-Gray code map and decoding using bit metric only)

Fig. 41



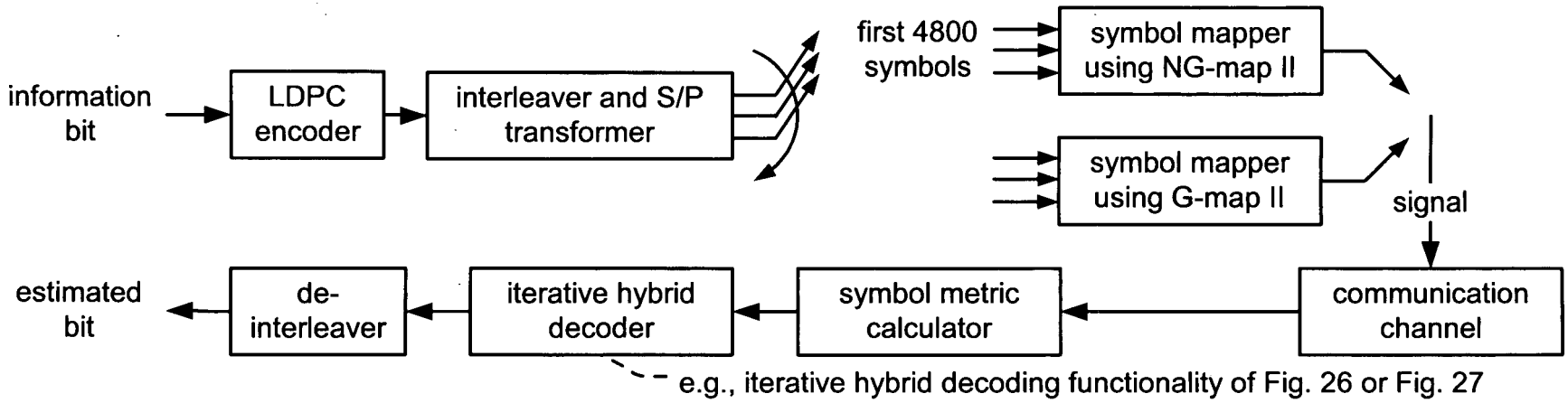
performance comparison of
2 bit/s/Hz LDPC-BICM communication
systems I, II, III, IV, and V
(50 decoding iterations)

Fig. 42



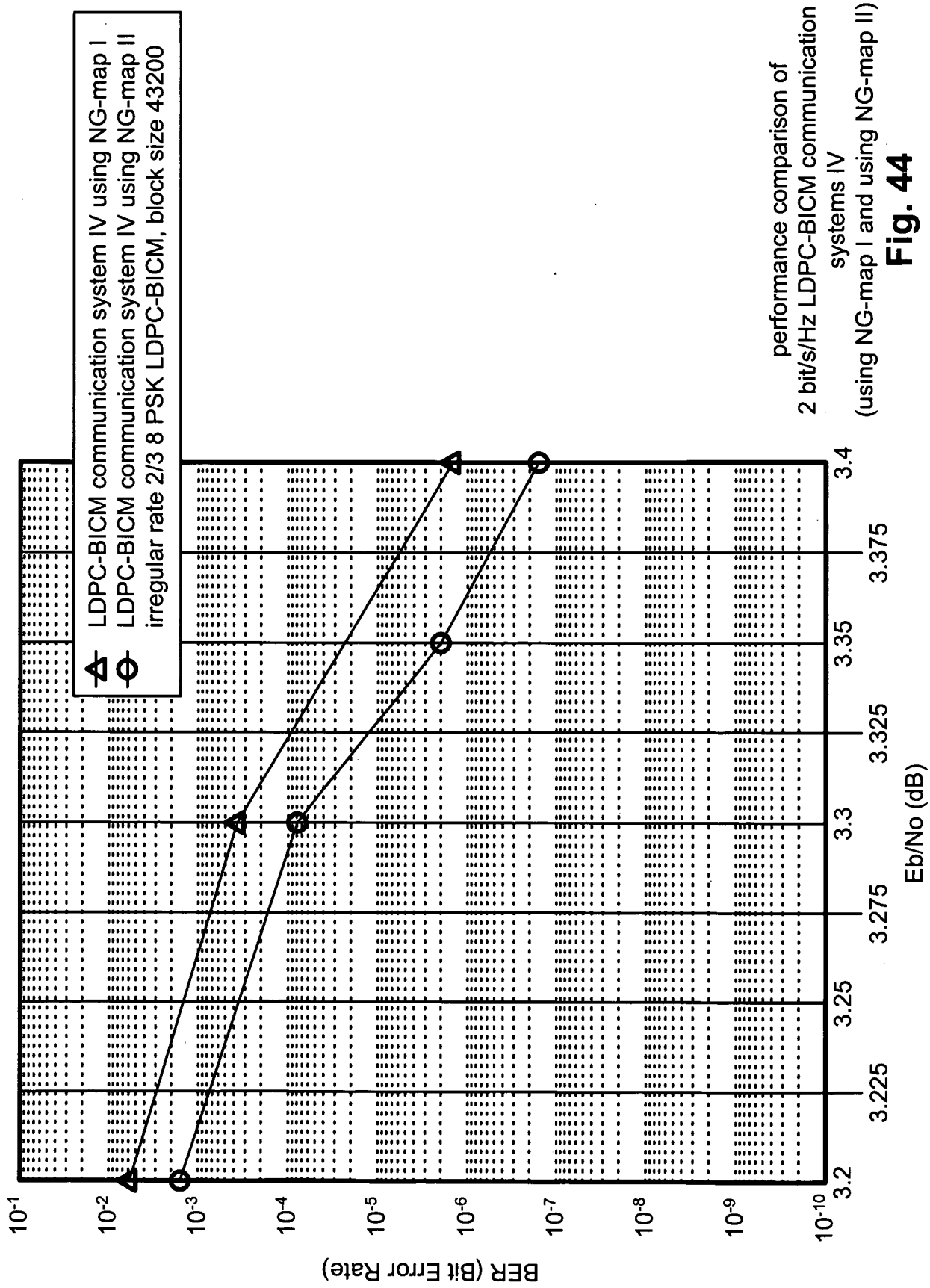
NG-map II (non-Gray code map) (shown using 8 PSK shaped constellation)

Fig. 43A



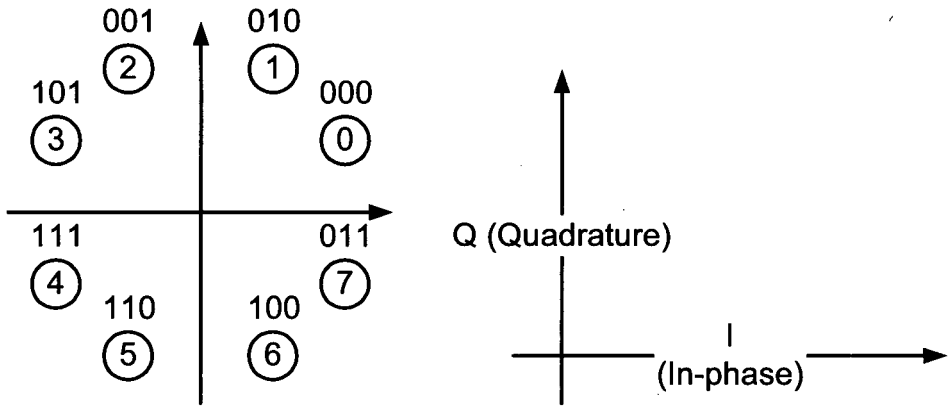
LDPC-BICM communication system IV using NG-map II (encoding using 1 Gray code map, 1 non-Gray code map and decoding using hybrid decoding approach)

Fig. 43B



performance comparison of
2 bit/s/Hz LDPC-BICM communication
systems IV
(using NG-map I and using NG-map II)

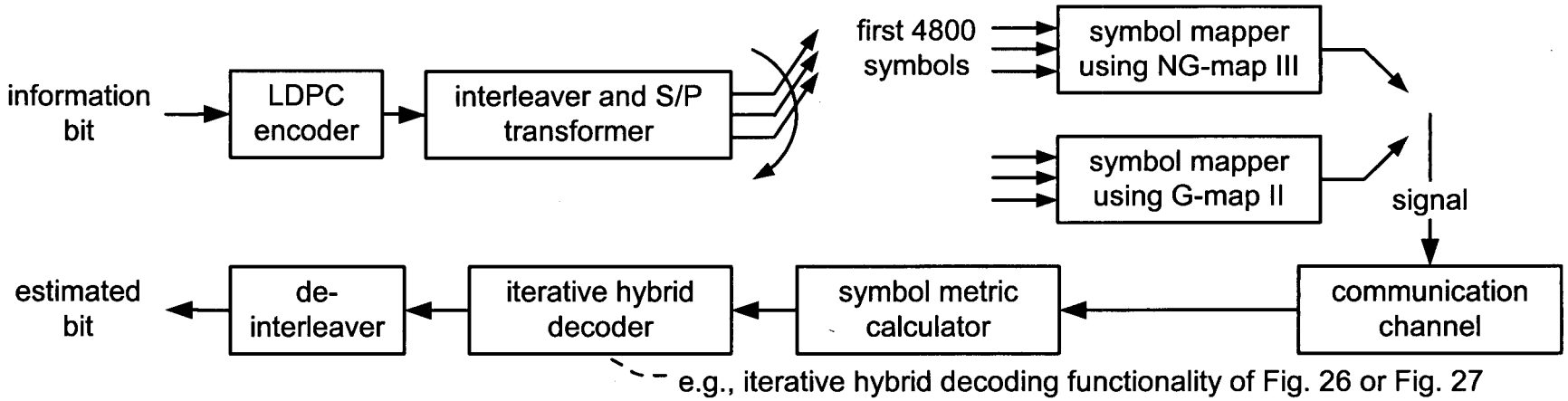
Fig. 44



NG-map III

NG-map III (non-Gray code map) (shown using 8 PSK shaped constellation)

Fig. 45A



LDPC-BICM communication system IV using NG-map II (encoding using 1 Gray code map, 1 non-Gray code map and decoding using hybrid decoding approach)

Fig. 45B

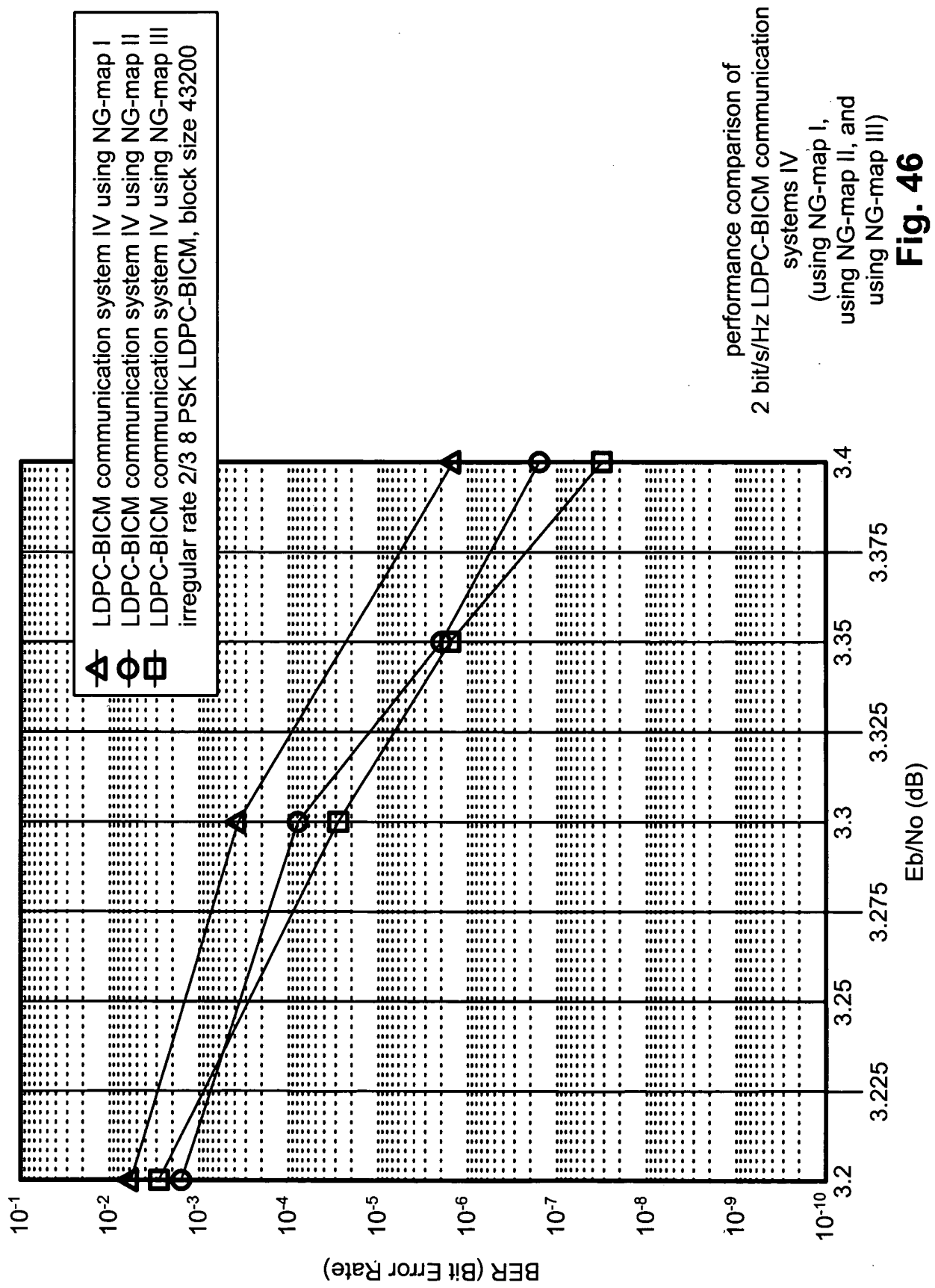
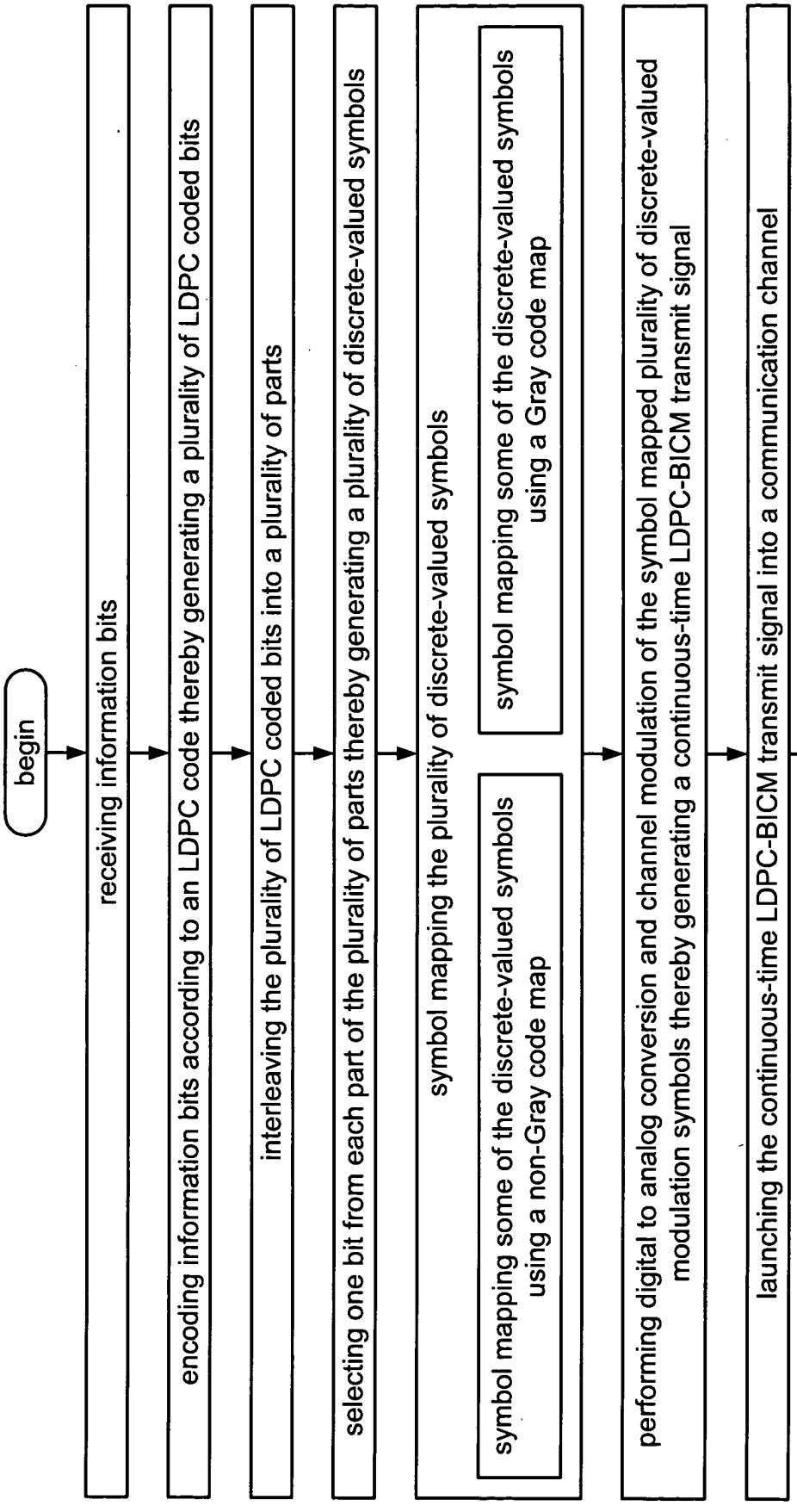
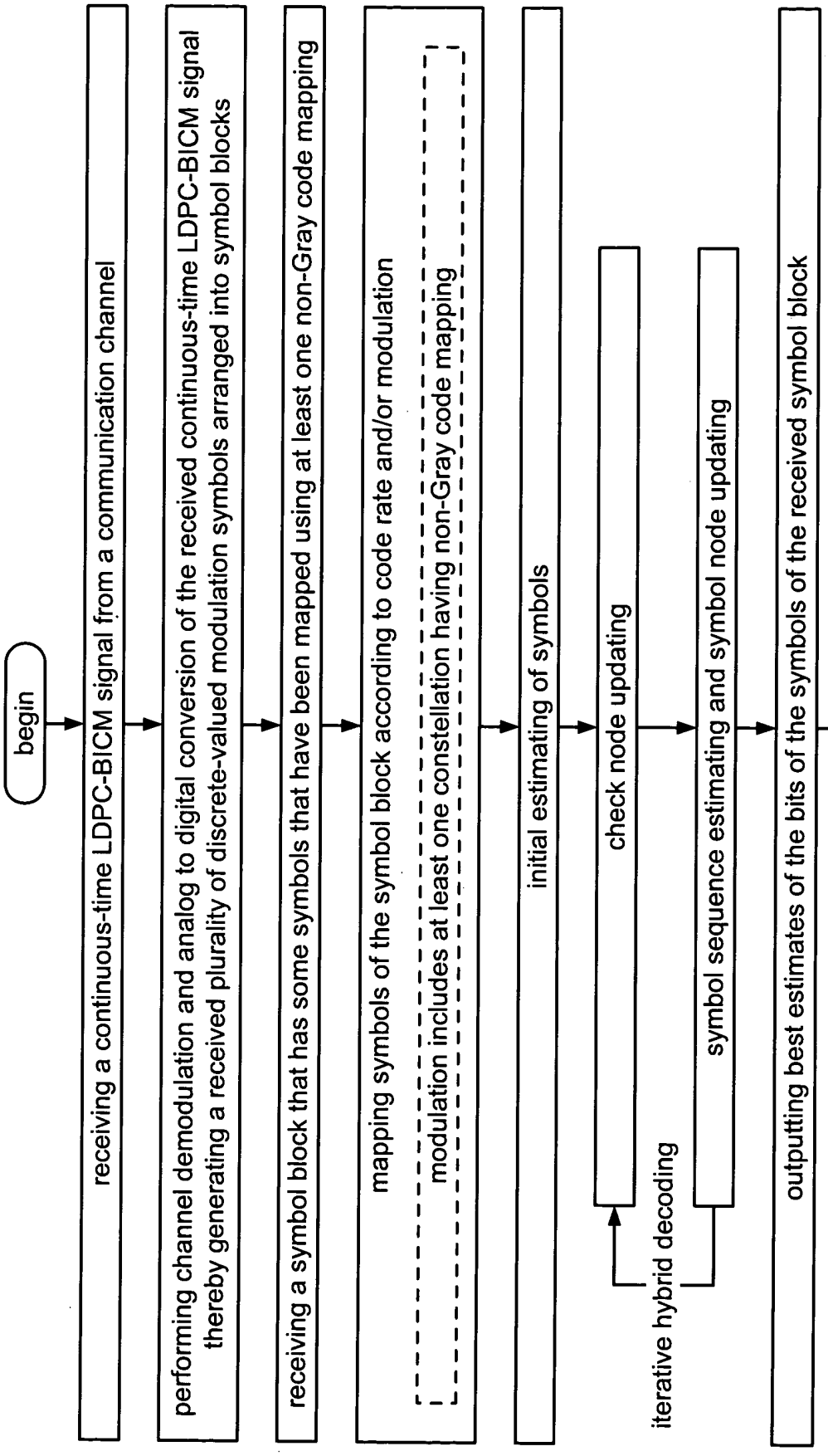

LDPC-BICM communication system IV using NG-map I
LDPC-BICM communication system IV using NG-map II
LDPC-BICM communication system IV using NG-map III
irregular rate 2/3 8 PSK LDPC-BICM, block size 43200
performance comparison of
2 bit/s/Hz LDPC-BICM communication
systems IV
(using NG-map I,
using NG-map II, and
using NG-map III)
BER (Bit Error Rate)
Eb/No (dB)
10-1
10-2
10-3
10-4
10-5
10-6
10-7
10-8
10-9
10-10
3.2
3.225
3.25
3.275
3.3
3.325
3.35
3.375
3.4

Fig. 46



method for generating an LDPC-BICM signal having a non-Gray code mapping

Fig. 47



method for hybrid decoding of LDPC-BICM signal having a non-Gray code mapping

Fig. 48